A319/A320/A321
TECHNICAL TRAINING MANUAL
SA Family to A319/A320/A321 CFM LEAP - T1+T2
70-STANDARD PRATICES - ENGINES

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POWER PLANT CFM LEAP-1A PRESENTATION

INTRODUCTION

The CFM LEAP-1A engine is an axial flow, dual-rotor, variable stator, high bypass ratio power plant. These engines power the A319, A320 and A321 aircraft of the Single Aisle (SA) New Engine Option (NEO) family. These engines reduce fuel consumption, air pollution and noise.
CFM International is a joint venture of GE and Safran Group's Snecma.
CFM LEAP-1A engines are available in several thrust ratings from 23000 lbs (10400 kg) to 33000 lbs (14900 kg).
For each model, the basic thrust ratings are referred with "1", reduced thrust ratings are referred with "2", increased thrust ratings are referred with "3".

A/C	A/C model	Rating	Max Thrust
A319	A319-151N	LEAP-1A24	24.4 klbs
	A319-152N	LEAP-1A23	22.9 klbs
	A319-153N	LEAP-1A26	26.6 klbs
A320	A320-251N	LEAP-1A26	26.6 klbs
	A320-252N	LEAP-1A24	24.4 klbs
	A320-253N	LEAP-1A29	29 klbs
A321	A321-251N	LEAP-1A32	32.1 klbs
	A321-252N	LEAP-1A30	29.7 klbs
	A321-253N	LEAP-1A33	32.9 klbs

MTOW: Maximum Take Off Weight
MLW: Maximum Landing Weight
MZFW: Maximum Zero Fuel Weight

INTRODUCTION

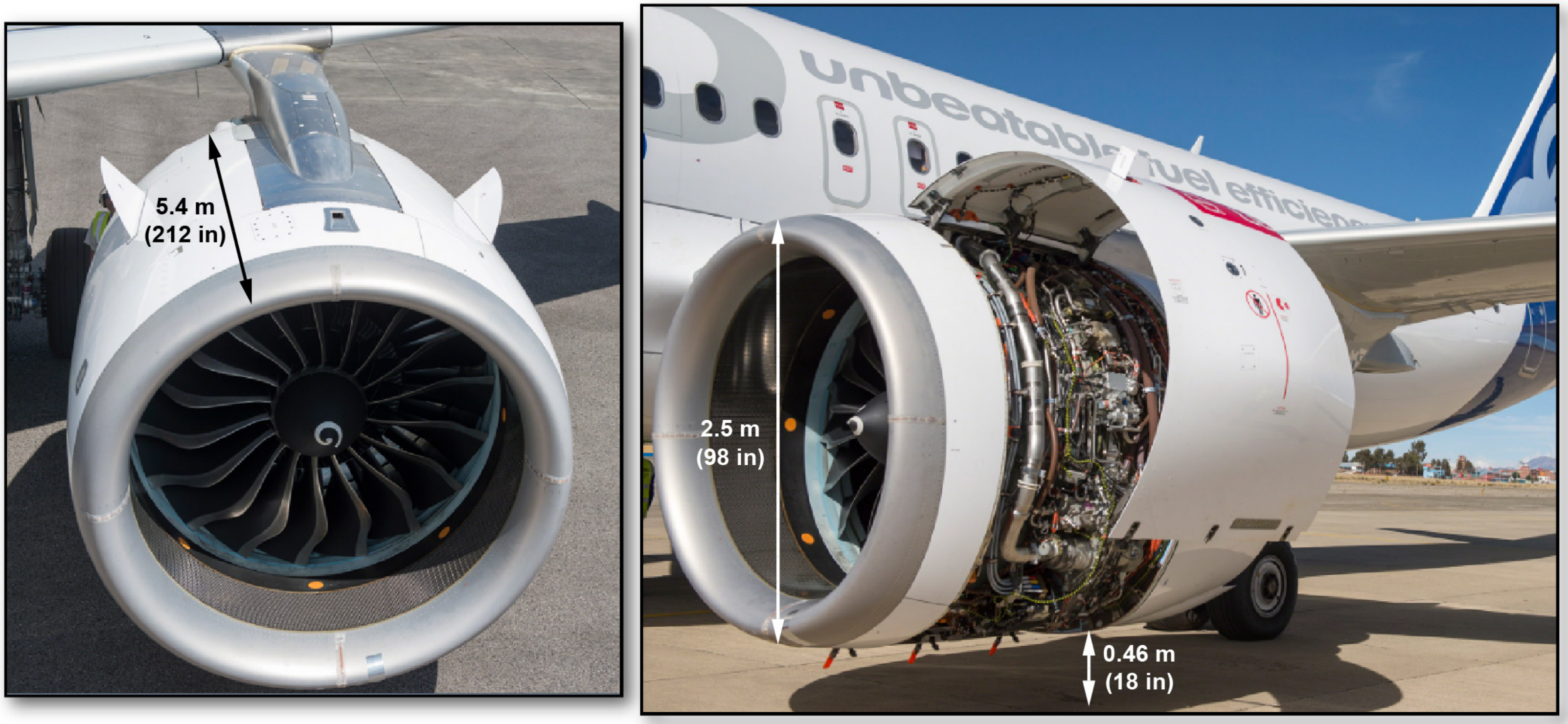
POWER PLANT CFM LEAP-1A PRESENTATION

INSTALLATION

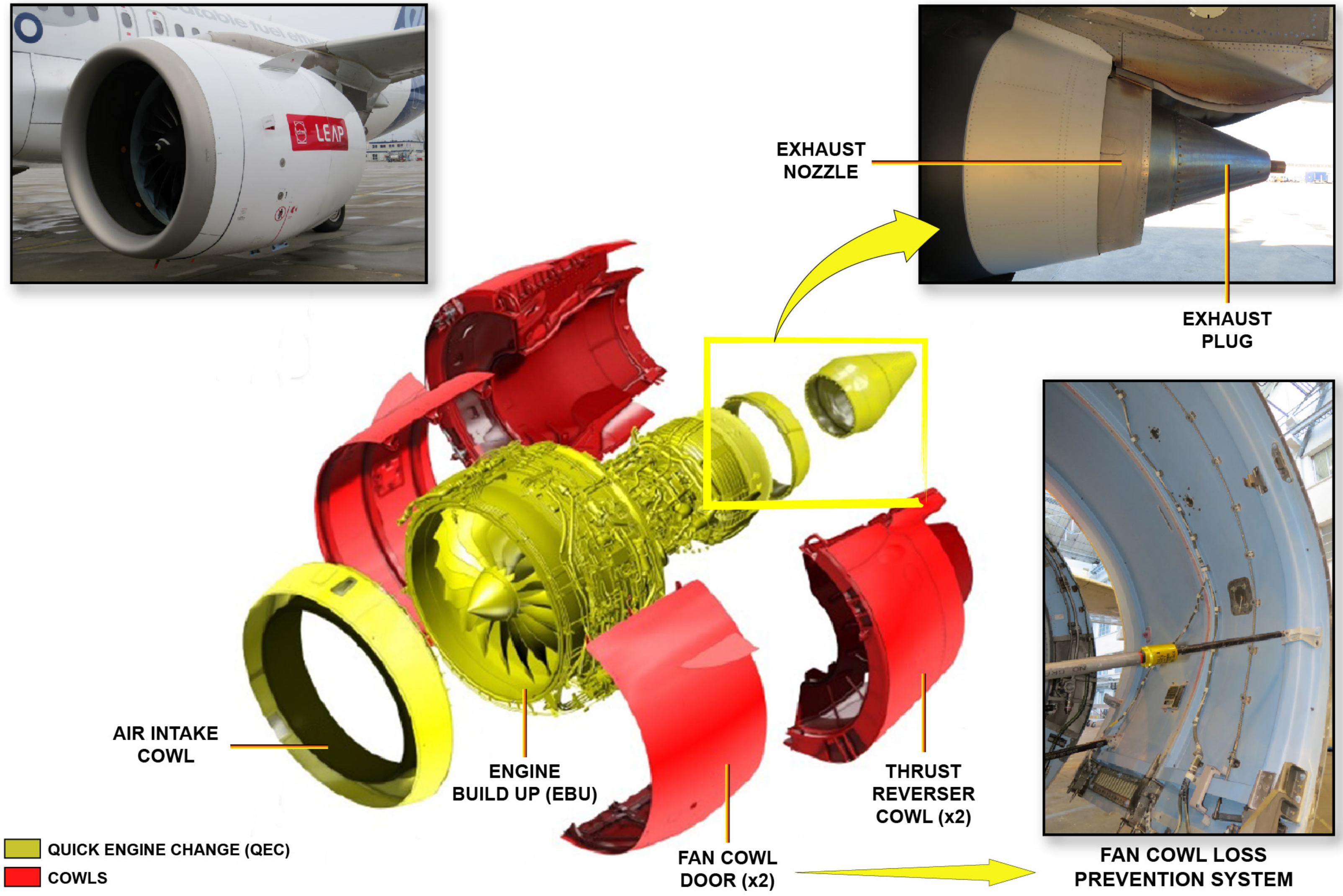
The engine is attached to the pylon by forward and aft mounts to transmit the engine and thrust loads.
The pylon connects the engine to the wing structure.
The engine nacelle:
- Ensures smooth airflow both around and into the engine,
- Protects the engine and the engine accessories,
- Provides engine noise attenuation,
- Permits access to the engine & its components for servicing.

The Powerplant major components are:
- Air Intake (or inlet) Cowl,
- Fan Cowl Doors with 3 latches,
- Thrust Reverser Cowl Doors with 8 latches,
- Engine Build up,
- Exhaust Nozzle and Plug.

NOTE: A Fan Cowl loss prevention system is installed:
- Mechanically with a flag,
- Electrically monitored by proximity switches.


5.4 m
(212 in)
2.5 m
(98 in)
0.46 m
(18 in)

INSTALLATION


EXHAUST NOZZLE
EXHAUST PLUG
AIR INTAKE COWL
ENGINE BUILD UP (EBU)
FAN COWL DOOR (x2)
THRUST REVERSER COWL (x2)
FAN COWL LOSS PREVENTION SYSTEM
🟨 QUICK ENGINE CHANGE (QEC)
🟥 COWLS
LEAP

INSTALLATION

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POWER PLANT CFM LEAP-1A PRESENTATION

ENGINE

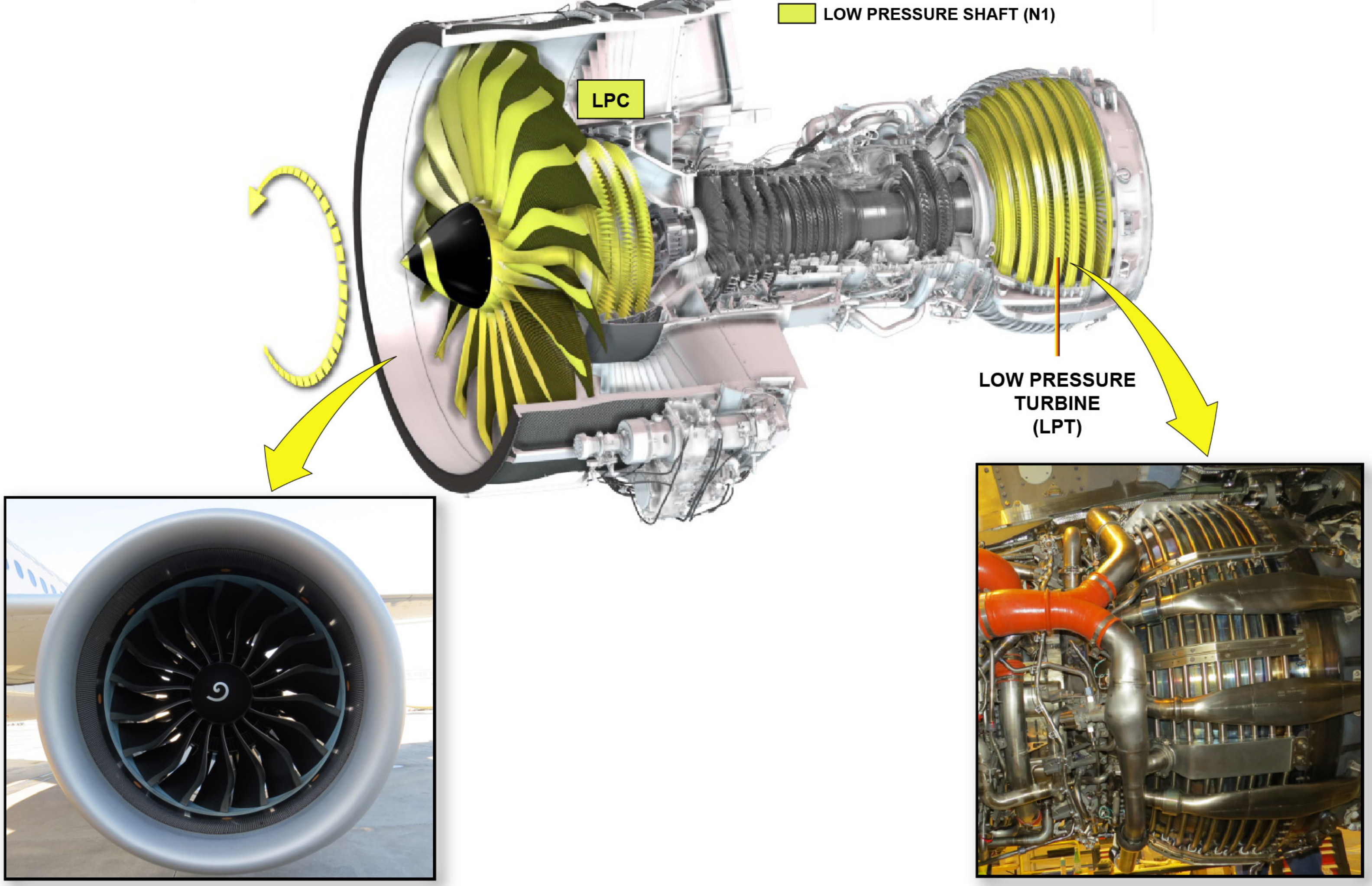
LP SHAFT

The CFM LEAP-1A is a high bypass ratio (BPR 11:1) dual spool turbofan.
The Low Pressure system is a direct drive architecture including:
- 18 blades
- 3
- -D woven carbon fiber composite fan (and composite fan case).

The fan supplies most of the engine thrust. The air produced by the fan is known as secondary or bypass airflow.
- A 3 stage booster supplies air to the engine core. This is primary airflow.
- 7 stage Low Pressure Turbine (LPT).

The speed of the LP rotor is indicated on the ECAM as N1.

LPC: Low Pressure Compressor


🟨 LOW PRESSURE SHAFT (N1)
LPC
LOW PRESSURE TURBINE (LPT)

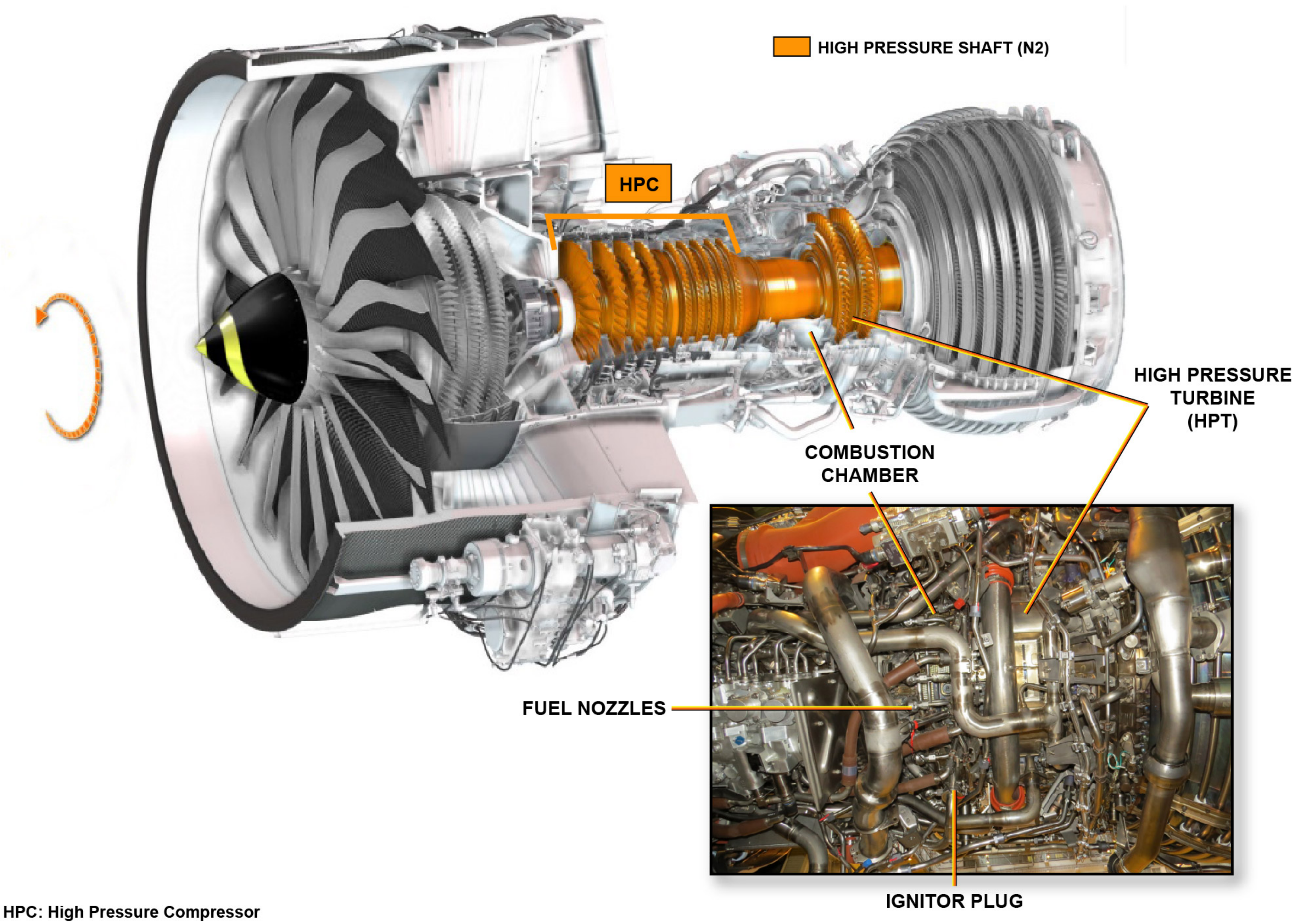
ENGINE - LP SHAFT

POWER PLANT CFM LEAP-1A PRESENTATION

ENGINE (continued)

HP SHAFT AND COMBUSTION CHAMBER

The High Pressure (HP) rotor is made up of 10 stages HP Compressor (HPC) driven by two stages HP Turbine (HPT). The speed of the HP rotor is indicated on the ECAM as N2.
The annular combustion chamber is installed between the HPC and HPT.
It has ports for 19 fuel nozzles and 2 igniter plugs.


🟧 HIGH PRESSURE SHAFT (N2)
HPC
HIGH PRESSURE TURBINE (HPT)
COMBUSTION CHAMBER
FUEL NOZZLES
IGNITOR PLUG

HPC: High Pressure Compressor

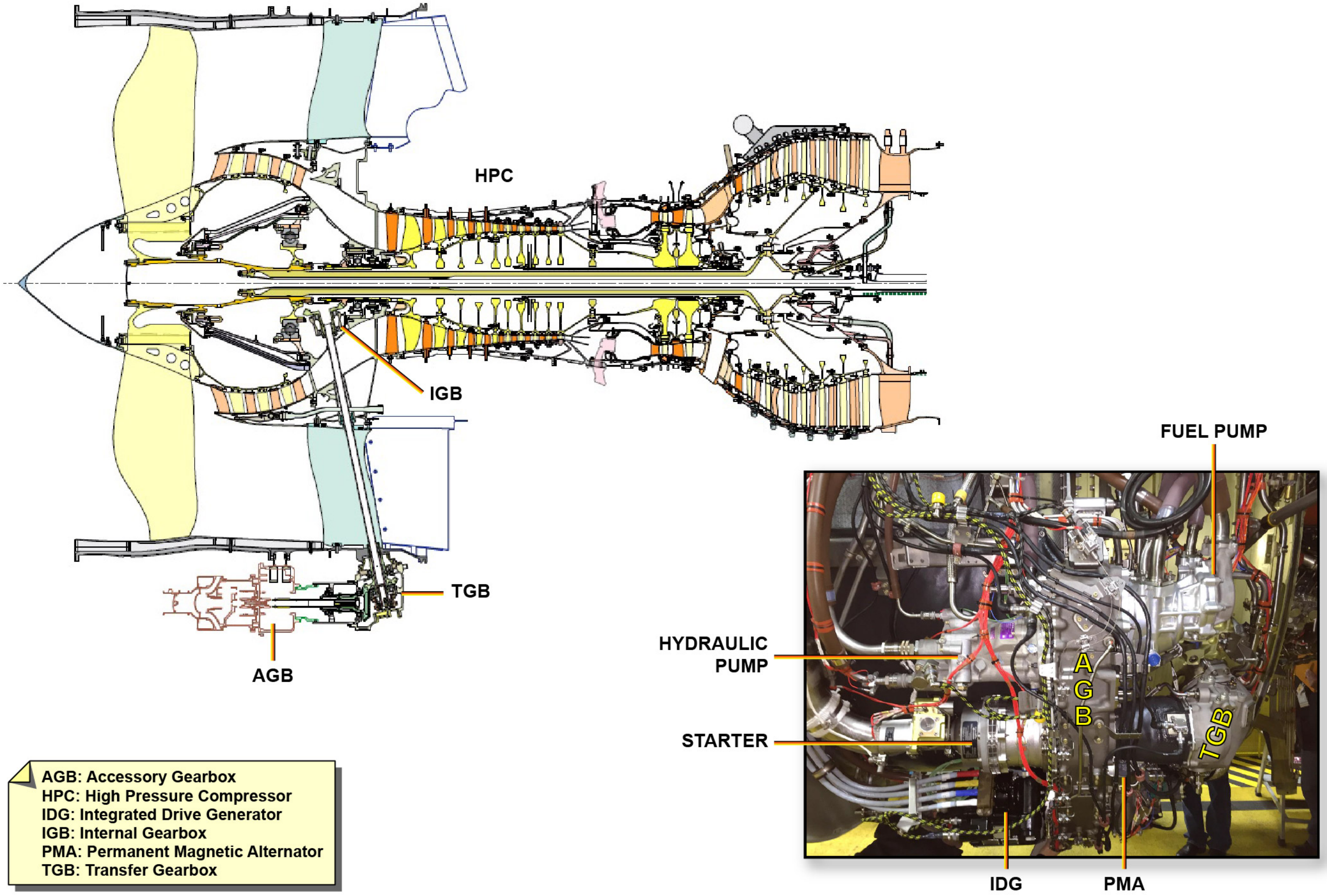
ENGINE - HP SHAFT AND COMBUSTION CHAMBER

POWER PLANT CFM LEAP-1A PRESENTATION

ENGINE (continued)

TRANSFER & ACCESSORY GEARBOXES

During starting, the pneumatic Starter provides torque to the Internal Gearbox (IGB) through the Transfer gearbox (TGB).
When engine runs, the HPC shaft drives the Accessory Gearbox (AGB) accessories through the IGB and the TGB.
The fuel pump, lubrication unit, hydraulic pump, Integrated Drive Generator (IDG) and FADEC Permanent Magnetic Alternator (PMA) are all driven by AGB.


HPC
IGB
TGB
AGB
FUEL PUMP
HYDRAULIC PUMP
STARTER
A
G
B
TGB
IDG
PMA

AGB: Accessory Gearbox
HPC: High Pressure Compressor
IDG: Integrated Drive Generator
IGB: Internal Gearbox
PMA: Permanent Magnetic Alternator
TGB: Transfer Gearbox

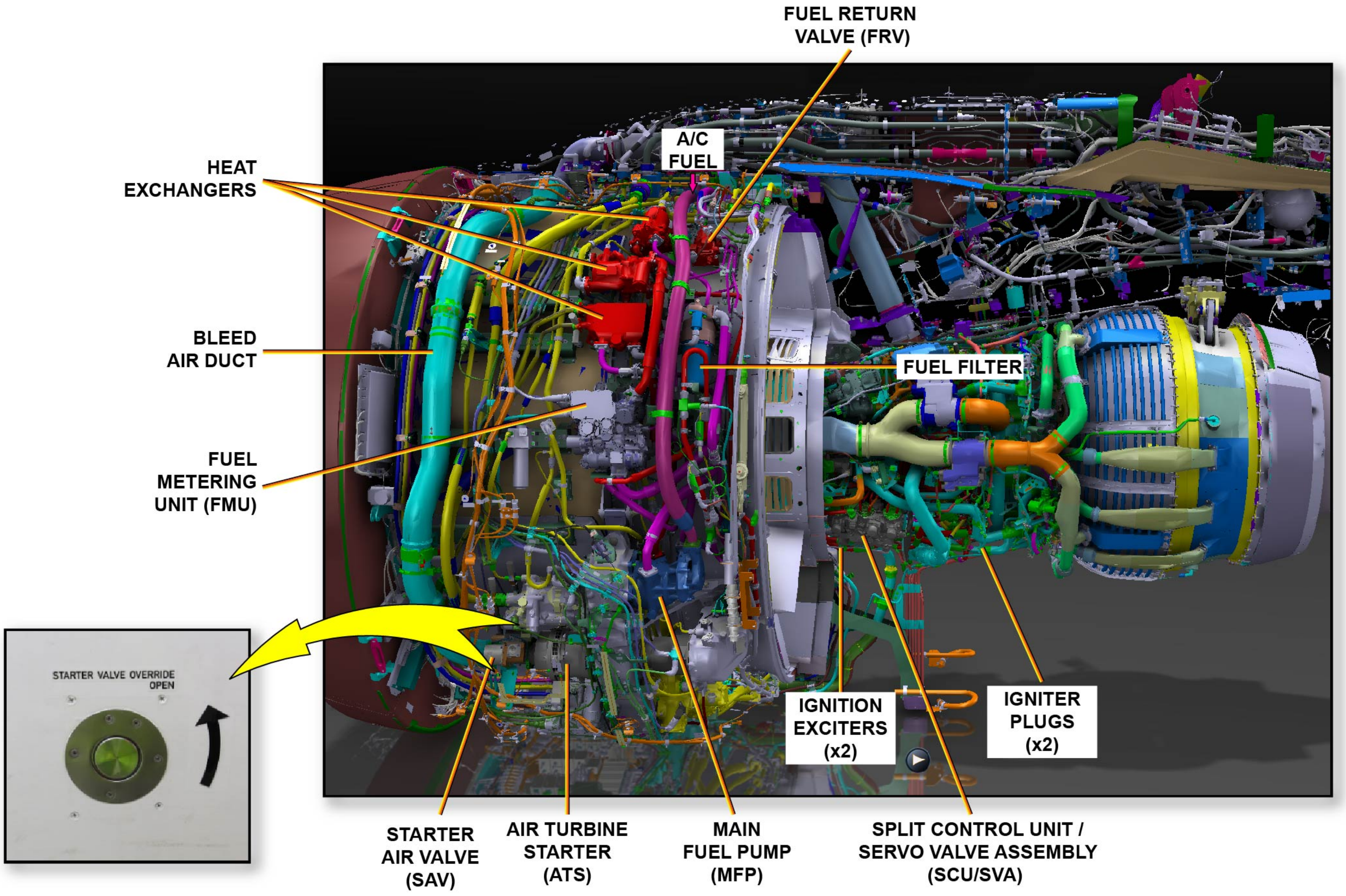
ENGINE - TRANSFER & ACCESSORY GEARBOXES

POWER PLANT CFM LEAP-1A PRESENTATION

FUEL AND STARTING

Fuel from the Aircraft tanks is pressurized, filtered, metered and supplied at the pressure and flow rate necessary to enable stable engine operations during all the phases.
The metered Fuel Flow is sent to the fuel nozzles for combustion and the Servo Fuel is supplies fuel-operated components.
The engine fuel system comprises:
- Main Fuel Pump (MFP),
- Fuel Filter,
- Fuel/Oil Heat exchangers (FOHX),
- Fuel Metering Unit (FMU),
- Split Control Unit/Servo Valve Assembly (SCU/SVA),
- 19 Fuel nozzles,
- Fuel Return Valve (FRV).

The Aircraft Pneumatic system supplies the bleed air for Engine starting via a bleed duct on the LH side, a Starter Air Valve (SAV) and the Air Turbine Starter (ATS).
Two igniters can produce sparks within the combustion chamber to ignite the air/fuel mixture.


FUEL RETURN VALVE (FRV)
A/C FUEL
HEAT EXCHANGERS
BLEED AIR DUCT
FUEL FILTER
FUEL METERING UNIT (FMU)
STARTER VALVE OVERRIDE OPEN
IGNITION EXCITERS (x2)
IGNITER PLUGS (x2)
STARTER AIR VALVE (SAV)
AIR TURBINE STARTER (ATS)
MAIN FUEL PUMP (MFP)
SPLIT CONTROL UNIT / SERVO VALVE ASSEMBLY (SCU/SVA)

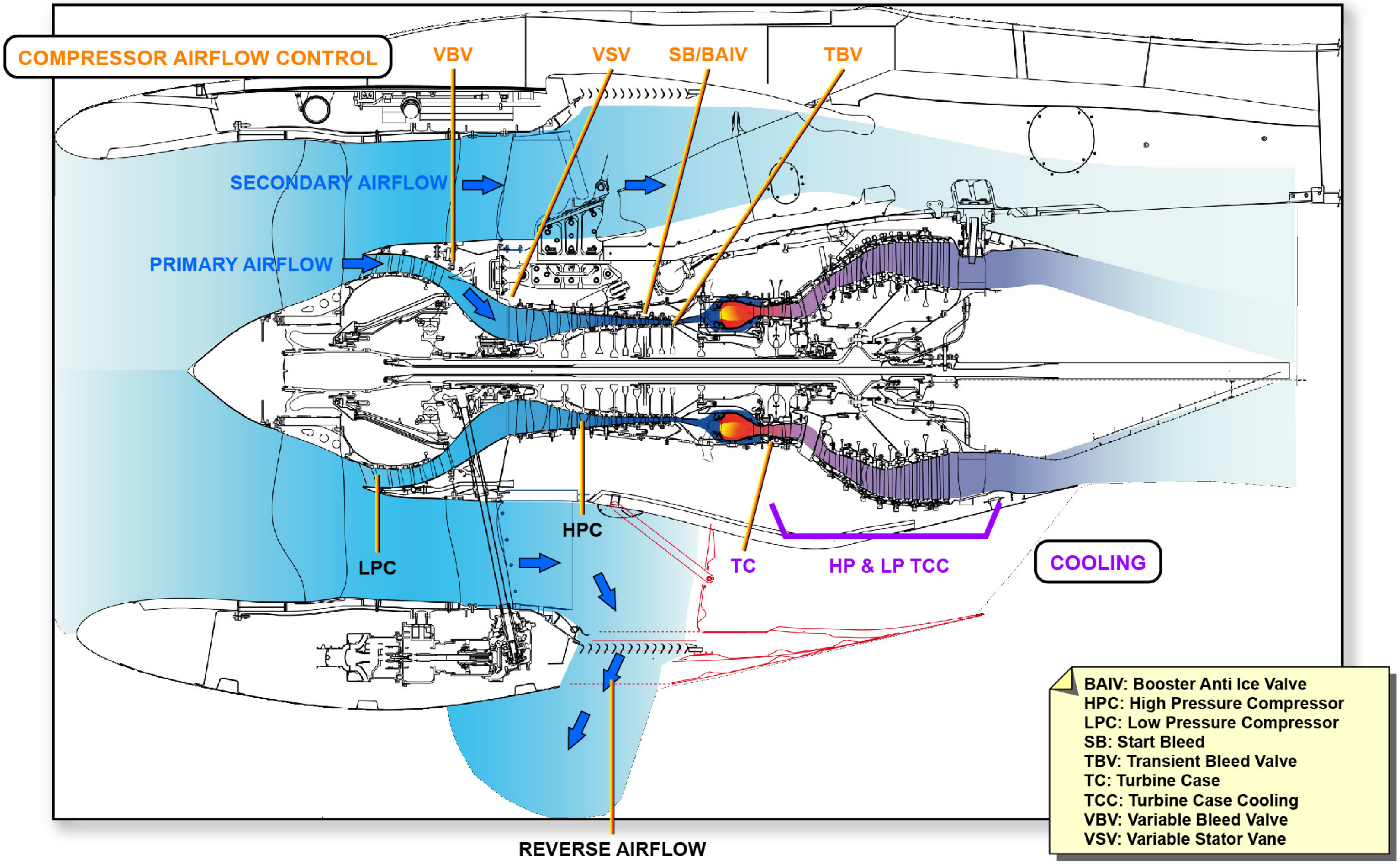
FUEL AND STARTING

POWER PLANT CFM LEAP-1A PRESENTATION

AIR SYSTEMS

The Compressor Airflow Control is done via the following:
- Variable Bleed Valves (VBVs) modulate primary airflow,
- Variable Stator Vane (VSV) system controls the amount of airflow in HPC,
- Start Bleed/Booster Anti Ice (SB/BAI) system eases starting and avoid icing on booster inlet using 7th HPC air discharge,
- Transient Bleed Valve (TBV) system discharges part of the HPC 10th stage air to unload the compressor.

The HP Turbine blades are internally cooled.
The HP and LP Turbines' cases are externally cooled by fan air.
The Engine core compartment and accessories are ventilated.


COMPRESSOR AIRFLOW CONTROL
VBV
VSV
SB/BAIV
TBV
SECONDARY AIRFLOW
PRIMARY AIRFLOW
HPC
LPC
TC
HP & LP TCC
COOLING
REVERSE AIRFLOW

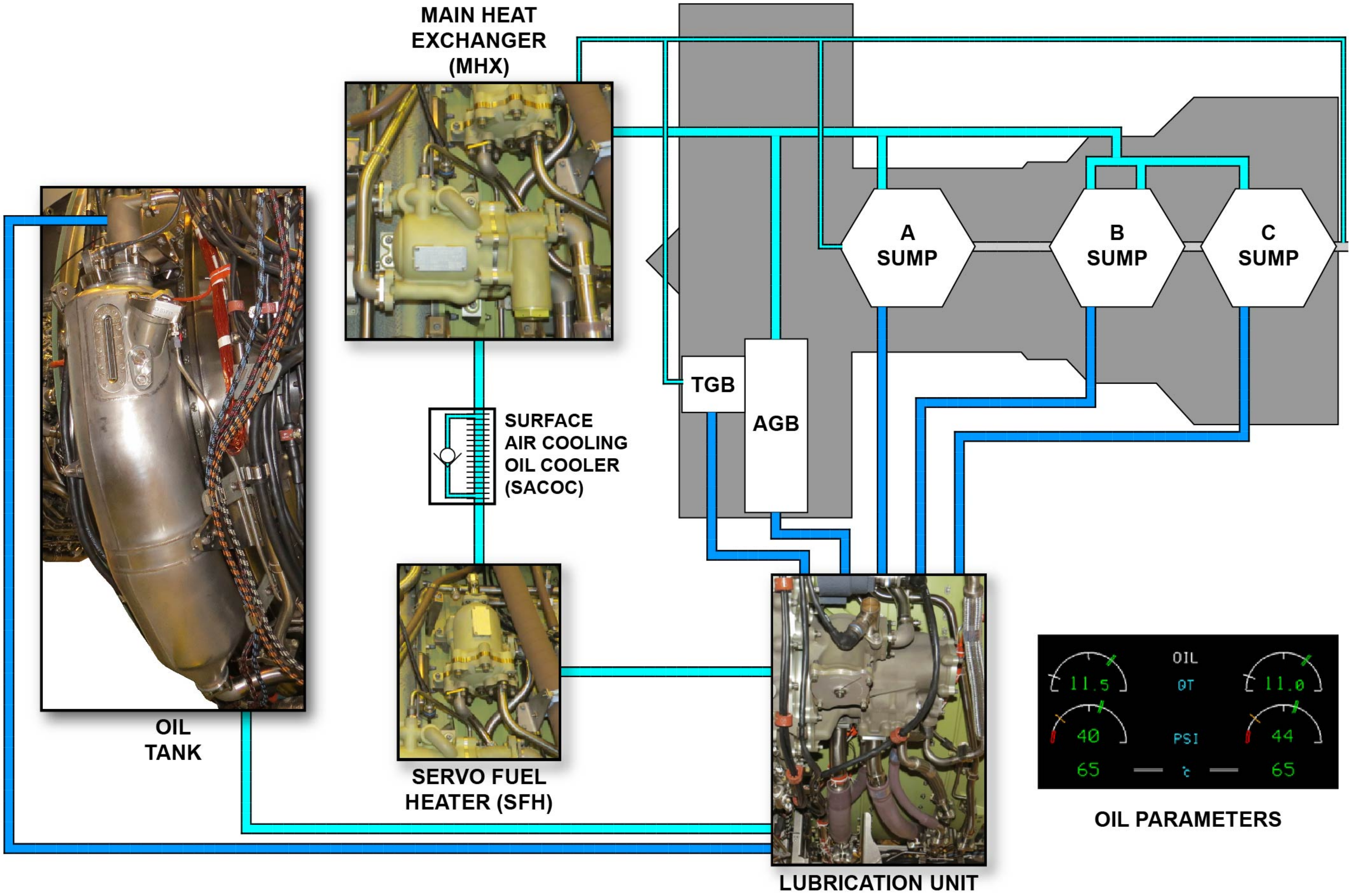
BAIV: Booster Anti Ice Valve
HPC: High Pressure Compressor
LPC: Low Pressure Compressor
SB: Start Bleed
TBV: Transient Bleed Valve
TC: Turbine Case
TCC: Turbine Case Cooling
VBV: Variable Bleed Valve
VSV: Variable Stator Vane

AIR SYSTEMS

POWER PLANT CFM LEAP-1A PRESENTATION

OIL SYSTEM

The oil system lubricates the engine bearings and gears.
The oil is supplied by the lubrication unit, cooled, filtered and scavenge back to the storage oil tank.
A vent circuit balances the internal air pressures.
The supply oil, cooled oil and the return oil parameters are monitored for ECAM warnings and indications.


MAIN HEAT EXCHANGER (MHX)
OIL TANK
SURFACE AIR COOLING OIL COOLER (SACOC)
SERVO FUEL HEATER (SFH)
TGB
AGB
A SUMP
B SUMP
C SUMP
LUBRICATION UNIT
OIL
QT
11.5
11.0
PSI
40
44
65
°C
65
OIL PARAMETERS

OIL SYSTEM

POWER PLANT CFM LEAP-1A PRESENTATION

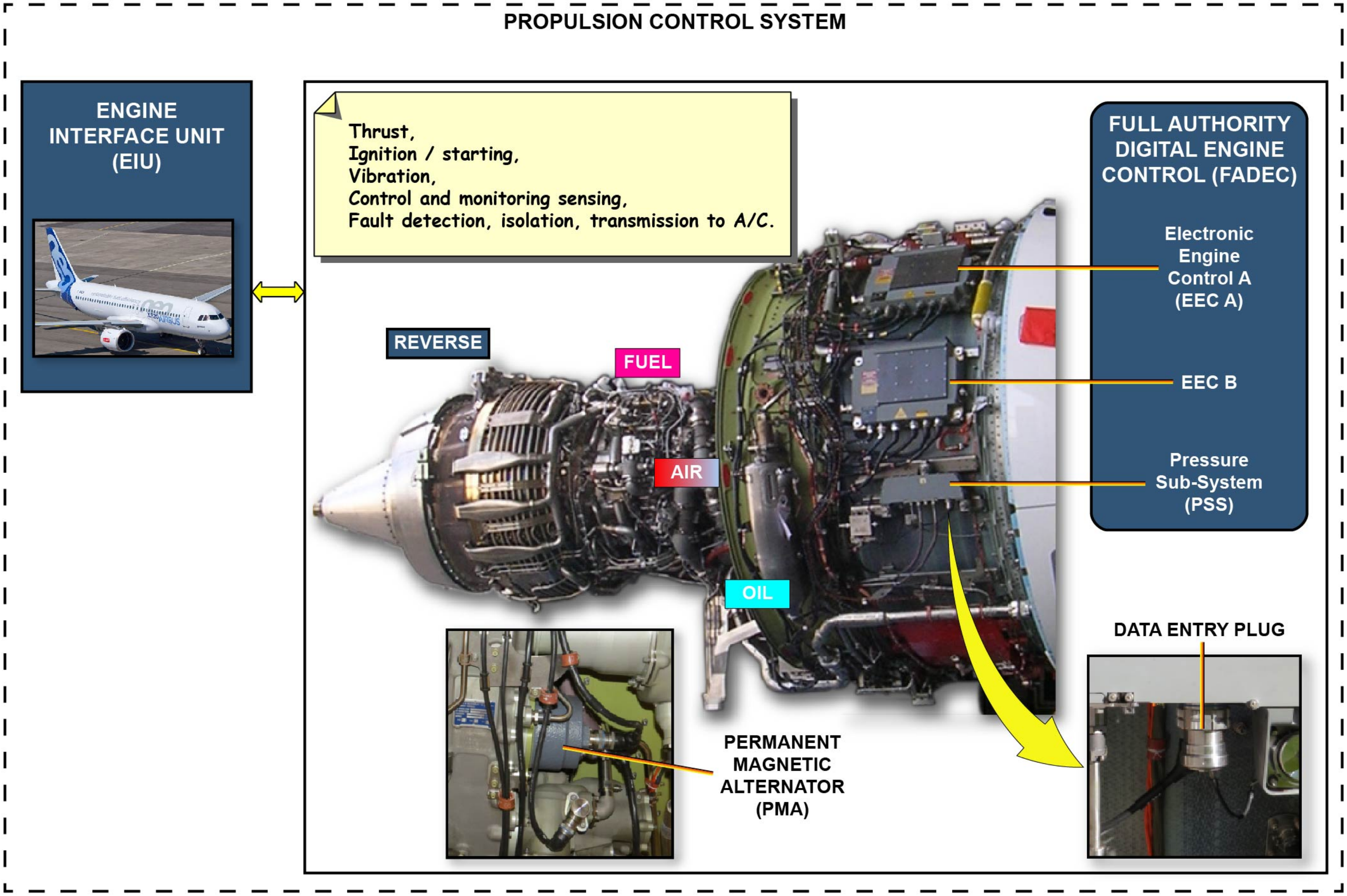
PROPULSION CONTROL SYSTEM (PCS) - FADEC

The Propulsion Control System (PCS) regroups the:
- FADEC system consists of 2 Electronic Engine Control (EEC) units and a Pressure Sub-System (PSS) box.
- Engine Interface Unit (EIU).

In order to increase engine reliability and efficiency, the FADEC gives the full range of engine control to achieve steady state and transient engine performances when operated in combination with aircraft subsystems.

The EEC controls the operation of the following:
- Engine control for thrust setting in Manual and Auto thrust Modes,
- Thrust Control Malfunction (TCM) protection,
- Engine airflow control,
- Combustor fuel metering valve,
- Control and monitoring sensing,
- Ignition and starting systems,
- Command and monitoring of the thrust reverser system,
- Fault detection, isolation, annunciation and transmission to the A/C (BITE).

When the engine is running, power for FADEC operation is supplied by a Permanent Magnet Alternator driven by the gearbox.



PROPULSION CONTROL SYSTEM

ENGINE INTERFACE UNIT (EIU)

Thrust,
Ignition / starting,
Vibration,
Control and monitoring sensing,
Fault detection, isolation, transmission to A/C.

FULL AUTHORITY DIGITAL ENGINE CONTROL (FADEC)

Electronic Engine Control A (EEC A)

EEC B

Pressure Sub-System (PSS)

REVERSE
FUEL
AIR
OIL
PERMANENT MAGNETIC ALTERNATOR (PMA)
DATA ENTRY PLUG

PROPULSION CONTROL SYSTEM (PCS) - FADEC

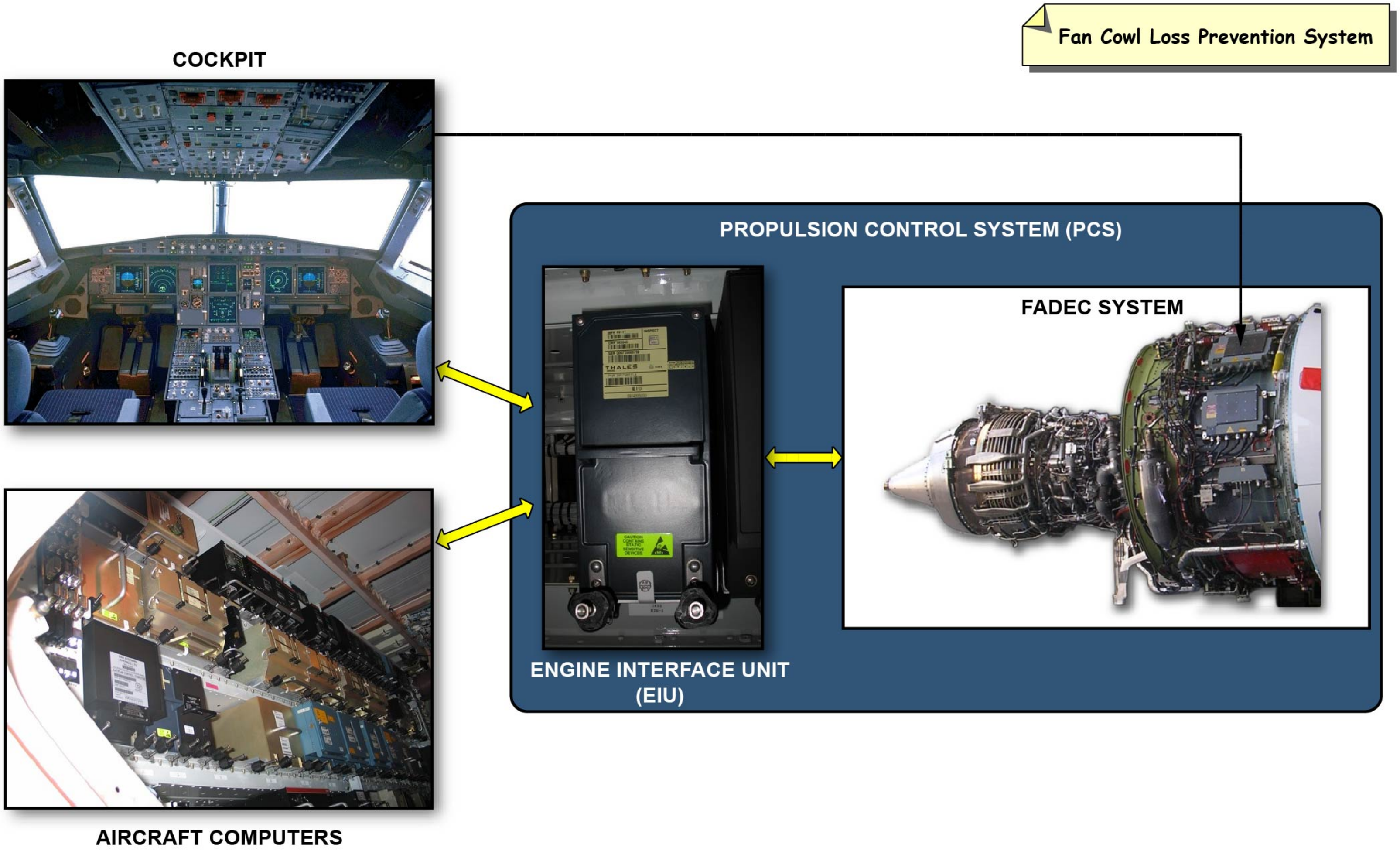
POWER PLANT CFM LEAP-1A PRESENTATION

PROPULSION CONTROL SYSTEM (PCS) - FADEC (continued)

PROPULSION CONTROL SYSTEM - EIU

The EIU is an interface concentrator between the airframe and the corresponding engine. Two EIUs are installed in the A/C.
EIU-1 interfaces with Engine 1 and EIU-2 interfaces with Engine 2.
The main functions of the EIU are:
- To concentrate data from cockpit panels and different aircraft systems to the associated EECs on each engine,
- To ensure the segregation of the two engines,
- To give to the airframe the necessary logic and information from engine and to other systems (APU, ECS, Bleed Air, Maintenance),
- To give to the FADEC system some necessary logic and information from systems (example: flight/ground status).

The Fan Cowl latches of the A320 NEO are monitored by proximity switches which send their position signals to the EIU.
The EIU transfers signals to the Flight Warning Computer (FWC) for associated cockpit warnings based on specific logic conditions.

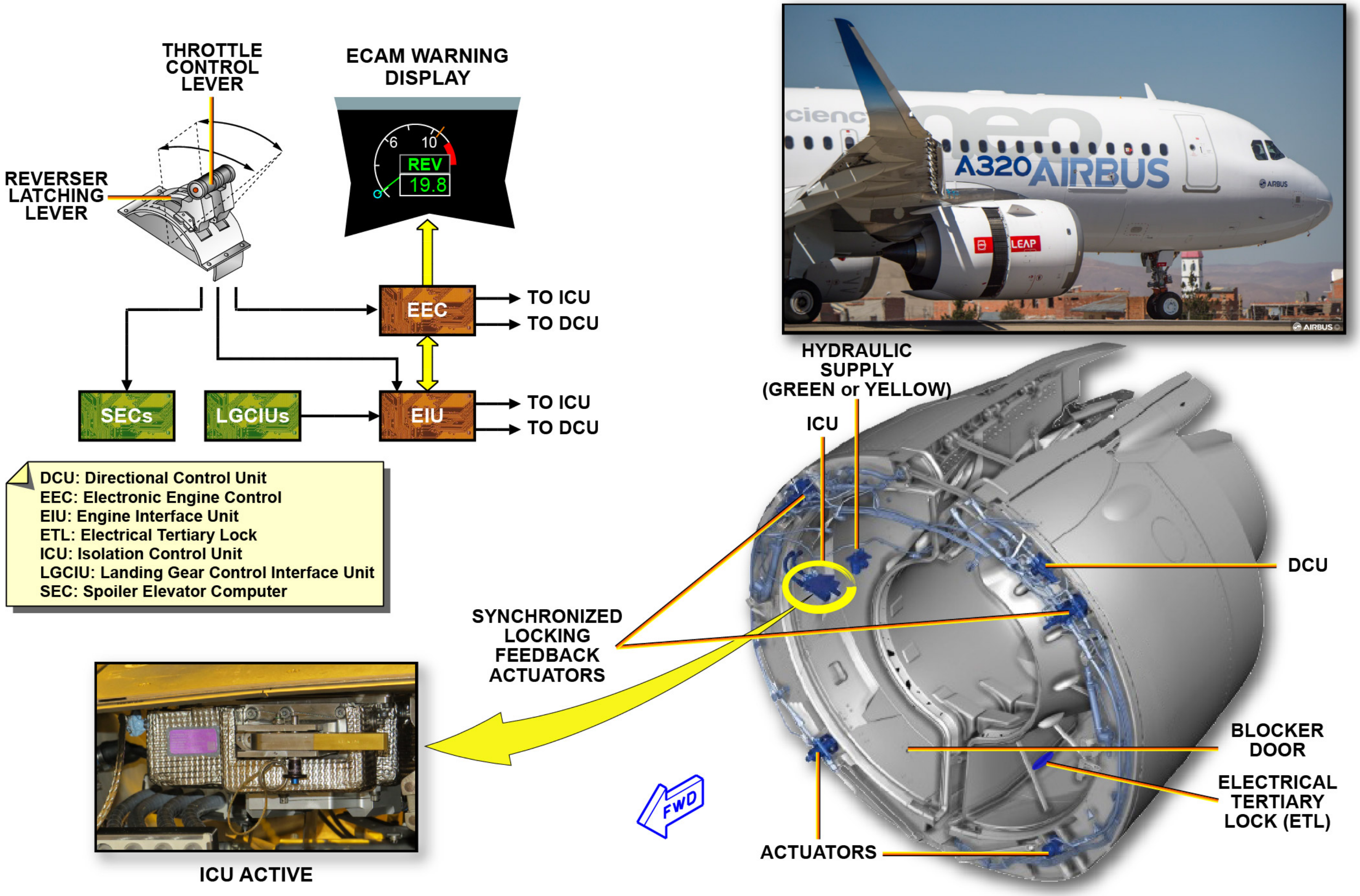

Fan Cowl Loss Prevention System
COCKPIT
PROPULSION CONTROL SYSTEM (PCS)
FADEC SYSTEM
ENGINE INTERFACE UNIT (EIU)
AIRCRAFT COMPUTERS

PROPULSION CONTROL SYSTEM (PCS) - FADEC - PROPULSION CONTROL SYSTEM - EIU

POWER PLANT CFM LEAP-1A PRESENTATION

THRUST REVERSER SYSTEM

The flight crew manually selects reverse thrust by lifting the latching levers on the throttle control levers on ground only.
The thrust reverser system operates 2 synchronized and mechanically linked translating sleeves, 10 blocker doors with cascade vanes per engine.
Isolation Control Unit (ICU) supplies hydraulic power to operate thrust reverser actuators.
The EEC in accordance with the EIU control the ICU and Directional Control Unit (DCU) for deploy and stow sequences with 4 actuators.
The Spoiler Elevator Computers (SECs) authorize unlocking of Electrical Tertiary Locks (ETLs).
For maintenance or dispatch the reverser system can be inhibited.


THROTTLE CONTROL LEVER
ECAM WARNING DISPLAY
6
10
REV
19.8
REVERSER LATCHING LEVER
EEC
TO ICU
TO DCU
SECs
LGCIUs
EIU
TO ICU
TO DCU
A320 AIRBUS
LEAP
HYDRAULIC SUPPLY (GREEN or YELLOW)
ICU
DCU
SYNCHRONIZED LOCKING FEEDBACK ACTUATORS
BLOCKER DOOR
ELECTRICAL TERTIARY LOCK (ETL)
ACTUATORS
FWD
ICU ACTIVE

DCU: Directional Control Unit
EEC: Electronic Engine Control
EIU: Engine Interface Unit
ETL: Electrical Tertiary Lock
ICU: Isolation Control Unit
LGCIU: Landing Gear Control Interface Unit
SEC: Spoiler Elevator Computer

THRUST REVERSER SYSTEM

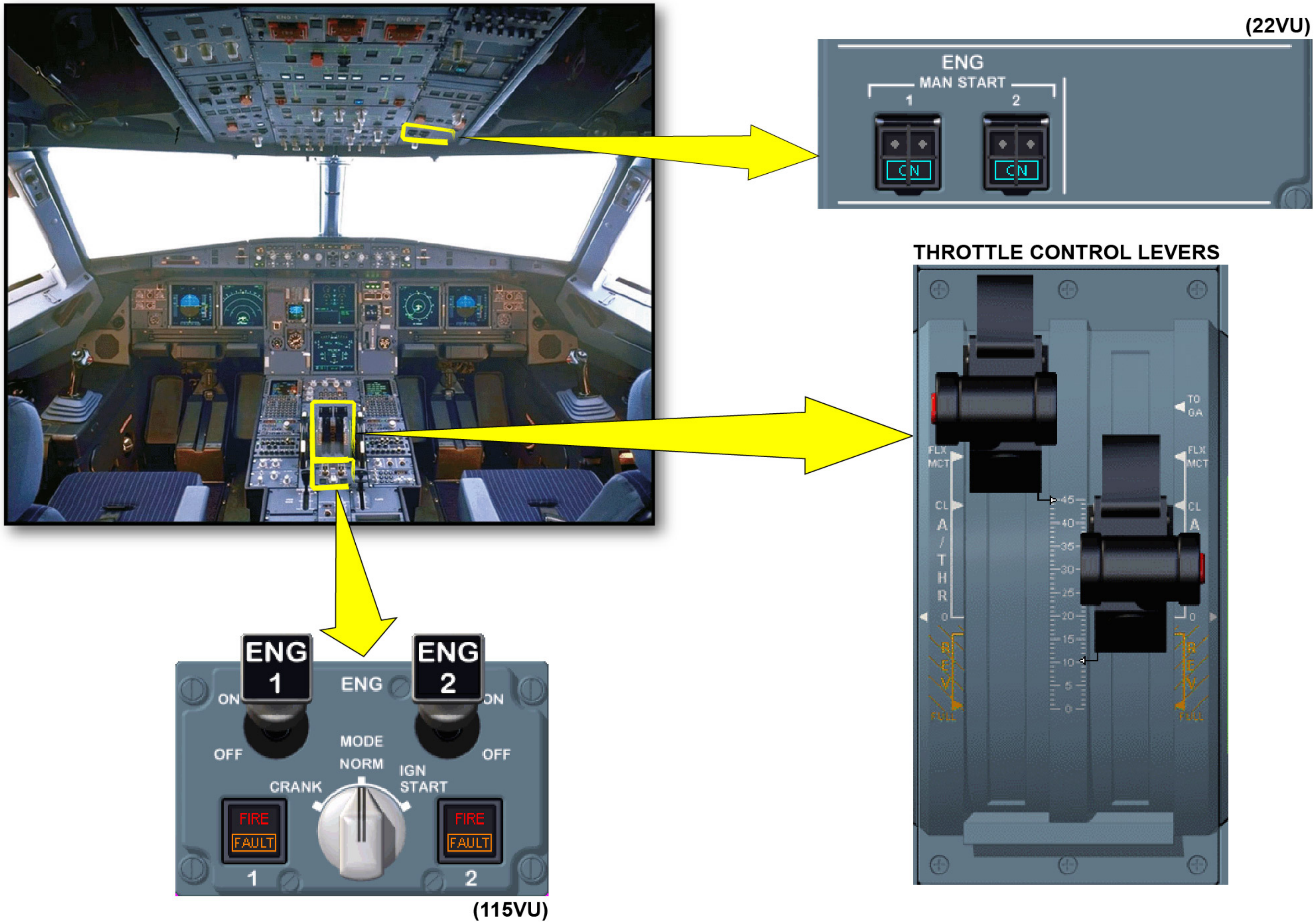
POWER PLANT CFM LEAP-1A PRESENTATION

CONTROL AND INDICATING

This section will highlight the control panels and indications for the engines.

CONTROL PANELS

The engines are controlled by throttle control levers which are installed on the center pedestal. They can only be moved manually.
For reverse thrust operation, two latching levers let the throttle control levers move rearward into the reverse thrust section.
The A320 family aircraft normally operate in the auto thrust mode, when in flight.
The autothrust can be disconnected with an instinctive disconnect pushbutton (2 red buttons are installed on the outside of the lever).
This lets the engines be controlled in manual thrust mode.
The controls for engine starting and shutdown are installed on the center pedestal immediately below the throttle control levers.
The engine MAN START switches are installed on the overhead panel. These switches are used to start an engine during a manual start procedure. They are also used during a dry or wet motoring procedure.


(22VU)
ENG
MAN START
1
2
ON
ON
THROTTLE CONTROL LEVERS
TO GA
FLX MCT
CL
A/THR
0
REV
FULL
45
40
35
30
25
20
15
10
5
0
ENG 1
ENG
ENG 2
ON
OFF
MODE
NORM
CRANK
IGN START
FIRE
FAULT
1
2
(115VU)

CONTROL AND INDICATING - CONTROL PANELS

POWER PLANT CFM LEAP-1A PRESENTATION

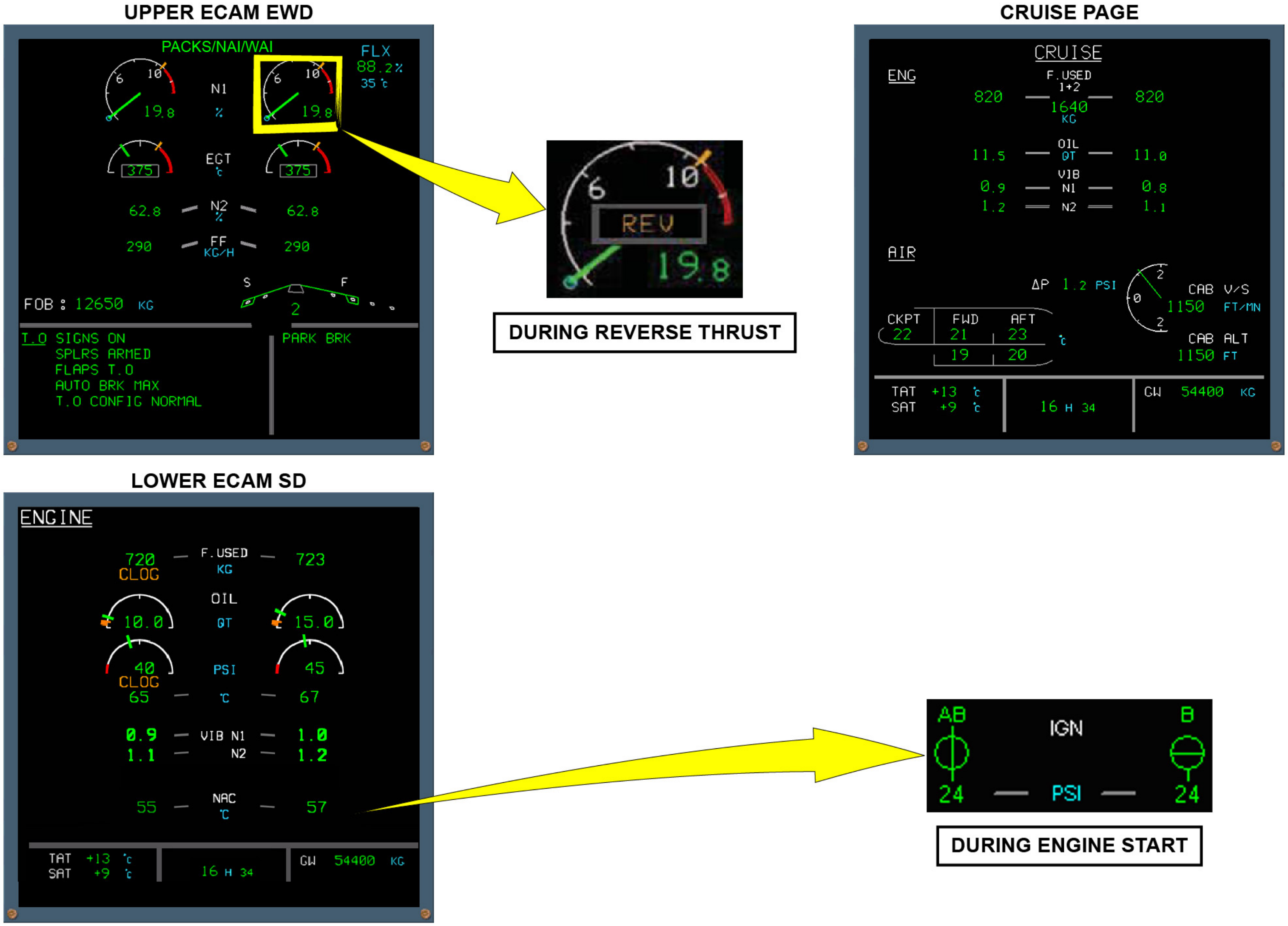
CONTROL AND INDICATING (continued)

ECAM ENGINE

The engine primary parameters are permanently displayed on the upper ECAM.

The engine secondary parameters are presented on the lower ECAM ENGINE page when selected or displayed automatically during engine start or a fault.

Some engine parameters are permanently displayed on the CRUISE page in flight.

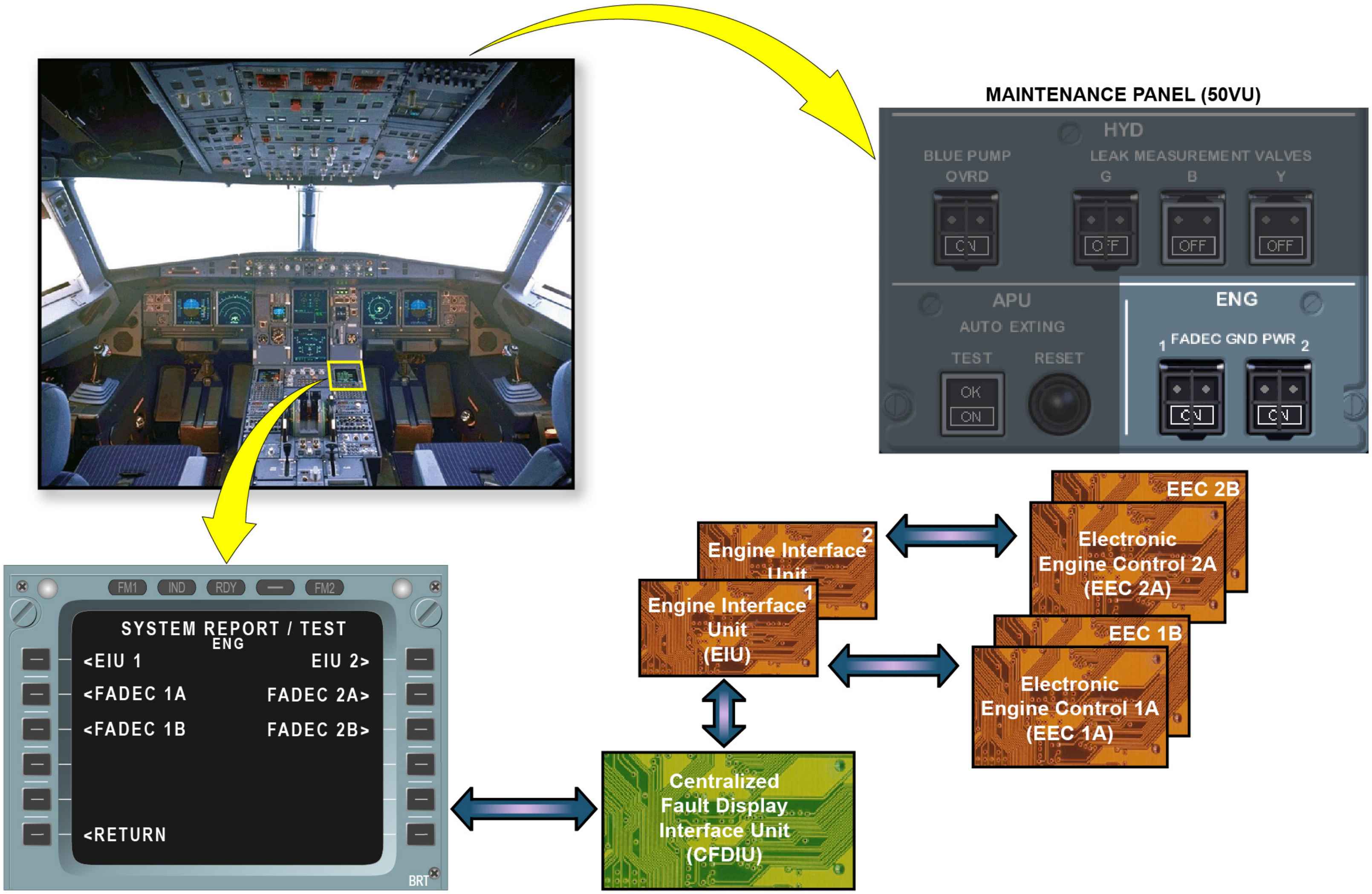

UPPER ECAM EWD
PACKS/NAI/WAI
FLX
88.2%
35 °C
6
10
19.8
N1
%
EGT
°C
375
N2
%
62.8
FF
KG/H
290
FOB : 12650 KG
S
F
2
T.O SIGNS ON
SPLRS ARMED
FLAPS T.O
AUTO BRK MAX
T.O CONFIG NORMAL
PARK BRK
REV
DURING REVERSE THRUST
CRUISE PAGE
CRUISE
ENG
F.USED
1+2
820
1640
KG
OIL
QT
11.5
11.0
VIB
N1
N2
0.9
0.8
1.2
1.1
AIR
ΔP 1.2 PSI
CAB V/S
1150 FT/MN
CAB ALT
1150 FT
CKPT
FWD
AFT
22
21
23
19
20
°C
TAT +13 °C
SAT +9 °C
16 H 34
GW 54400 KG
LOWER ECAM SD
ENGINE
720
CLOG
F.USED
KG
723
OIL
10.0
QT
15.0
40
CLOG
PSI
45
65
°C
67
0.9
VIB N1
1.0
1.1
N2
1.2
55
NAC
°C
57
TAT +13 °C
SAT +9 °C
16 H 34
GW 54400 KG
AB
IGN
B
24
PSI
24
DURING ENGINE START

CONTROL AND INDICATING - ECAM ENGINE

POWER PLANT CFM LEAP-1A PRESENTATION

MAINTENANCE/TEST FACILITIES

On the maintenance panel, the ENG FADEC GND PWR permits to supply the FADEC system for maintenance tasks, when the engines are not running.
The Multipurpose Control and Display Unit (MCDU) is used to do PCS tests and for trouble shooting monitored components (computers, sensors, actuators).


MAINTENANCE PANEL (50VU)
HYD
BLUE PUMP OVRD
LEAK MEASUREMENT VALVES
G
B
Y
ON
OFF
OFF
OFF
APU
AUTO EXTING
TEST
RESET
OK
ON
ENG
1 FADEC GND PWR 2
ON
ON
FM1
IND
RDY
FM2
SYSTEM REPORT / TEST
ENG
<EIU 1
EIU 2>
<FADEC 1A
FADEC 2A>
<FADEC 1B
FADEC 2B>
<RETURN
BRT
Engine Interface Unit 2
Engine Interface Unit (EIU) 1
Centralized Fault Display Interface Unit (CFDIU)
EEC 2B
Electronic Engine Control 2A (EEC 2A)
EEC 1B
Electronic Engine Control 1A (EEC 1A)

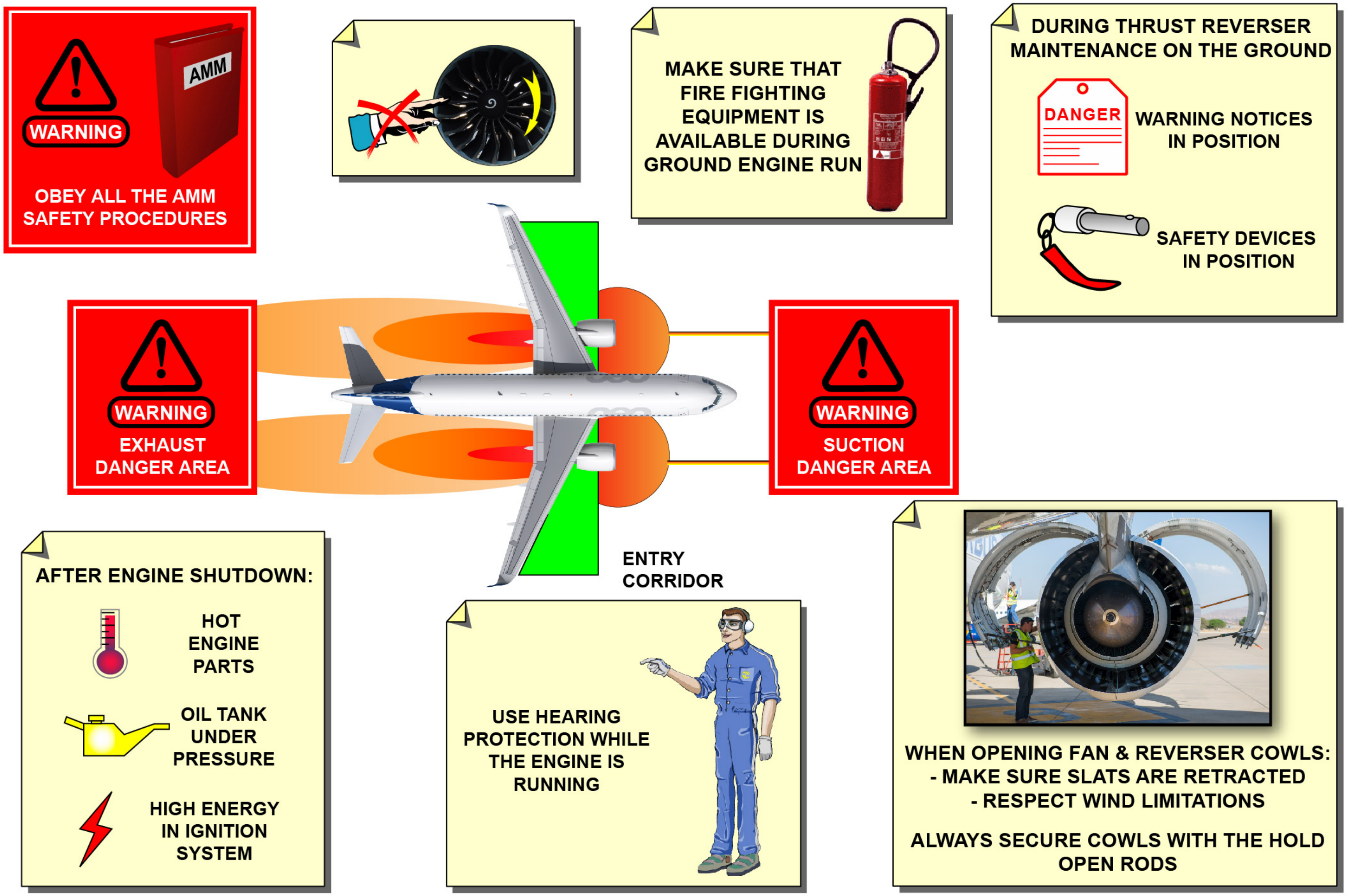
MAINTENANCE/TEST FACILITIES

POWER PLANT CFM LEAP-1A PRESENTATION

SAFETY PRECAUTIONS

When you work on aircraft, make sure that you obey all the Aircraft Maintenance Manual (AMM) safety procedures.
This will prevent injury to persons and/or damage to the aircraft. Here is an overview of main safety precautions related to the engines.
Make sure that all engine danger areas are as clear as possible to prevent damage to the engine, the aircraft or persons in the area.
Be careful: The entry corridor will be closed when the engine power is above the minimum.
Make sure that you have fire-fighting equipment available.
Do not try to stop the fan from turning by hand.
After engine shutdown, let the oil tank pressure bleed off for a minimum of 5 minutes before you remove the tank filler cap. If you do not, pressurized oil can flow out of the tank and cause dangerous burns.
The engine ignition system is an electrical system with high energy. You must be careful to prevent electrical shock. Injury or death can occur. Do not do maintenance on the ignition system while the engine operates.
Make sure that the engine shutdown occurred more than 5 minutes ago before you continue with the maintenance procedure.
Make sure that the thrust reverser is deactivated during maintenance. If not, the thrust reverser can operate accidentally and cause injury to personnel and/or damage to the reverser.
When opening the engine cowls:

- Respect the wind limitations and the opening/closing sequence,
- Always secure cowls with the hold-open rods,
- Make sure that the slats are retracted and install a warning notice to prevent slat operation.



WARNING

OBEY ALL THE AMM SAFETY PROCEDURES

MAKE SURE THAT FIRE FIGHTING EQUIPMENT IS AVAILABLE DURING GROUND ENGINE RUN

DURING THRUST REVERSER MAINTENANCE ON THE GROUND

WARNING NOTICES IN POSITION

SAFETY DEVICES IN POSITION

WARNING

EXHAUST DANGER AREA

WARNING

SUCTION DANGER AREA

ENTRY CORRIDOR

AFTER ENGINE SHUTDOWN:

HOT ENGINE PARTS

OIL TANK UNDER PRESSURE

HIGH ENERGY IN IGNITION SYSTEM

USE HEARING PROTECTION WHILE THE ENGINE IS RUNNING

WHEN OPENING FAN & REVERSER COWLS:
- MAKE SURE SLATS ARE RETRACTED
- RESPECT WIND LIMITATIONS

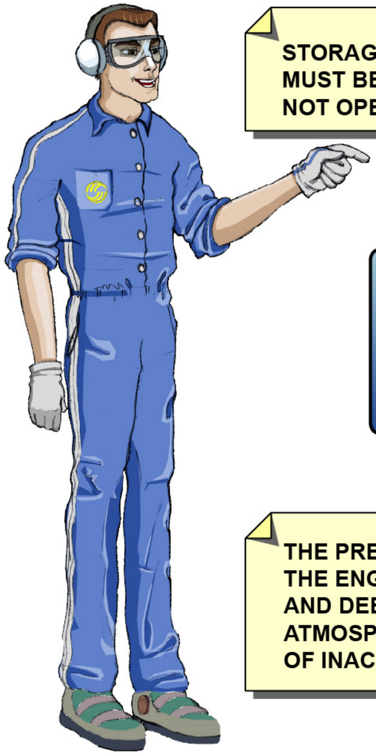
ALWAYS SECURE COWLS WITH THE HOLD OPEN RODS

SAFETY PRECAUTIONS

POWER PLANT CFM LEAP-1A PRESENTATION

STORAGE AND PRESERVATION

Storage and preservation procedures must be applied to engines which are not operated. The preservation procedures protect the engine against corrosion, liquid and debris entering the engine, and atmospheric conditions during period of inactivity.



STORAGE AND PRESERVATION PROCEDURES MUST BE APPLIED FOR ENGINES WHICH ARE NOT OPERATED.

PROTECTION AGAINST ATMOSPHERIC CONDITIONS

❄ ☀ 🌧

THE PRESERVATION PROCEDURES PROTECT THE ENGINE AGAINST CORROSION, LIQUID AND DEBRIS ENTERING THE ENGINE, AND ATMOSPHERIC CONDITIONS DURING PERIOD OF INACTIVITY.

unbeatable fuel efficiency

CAUTION

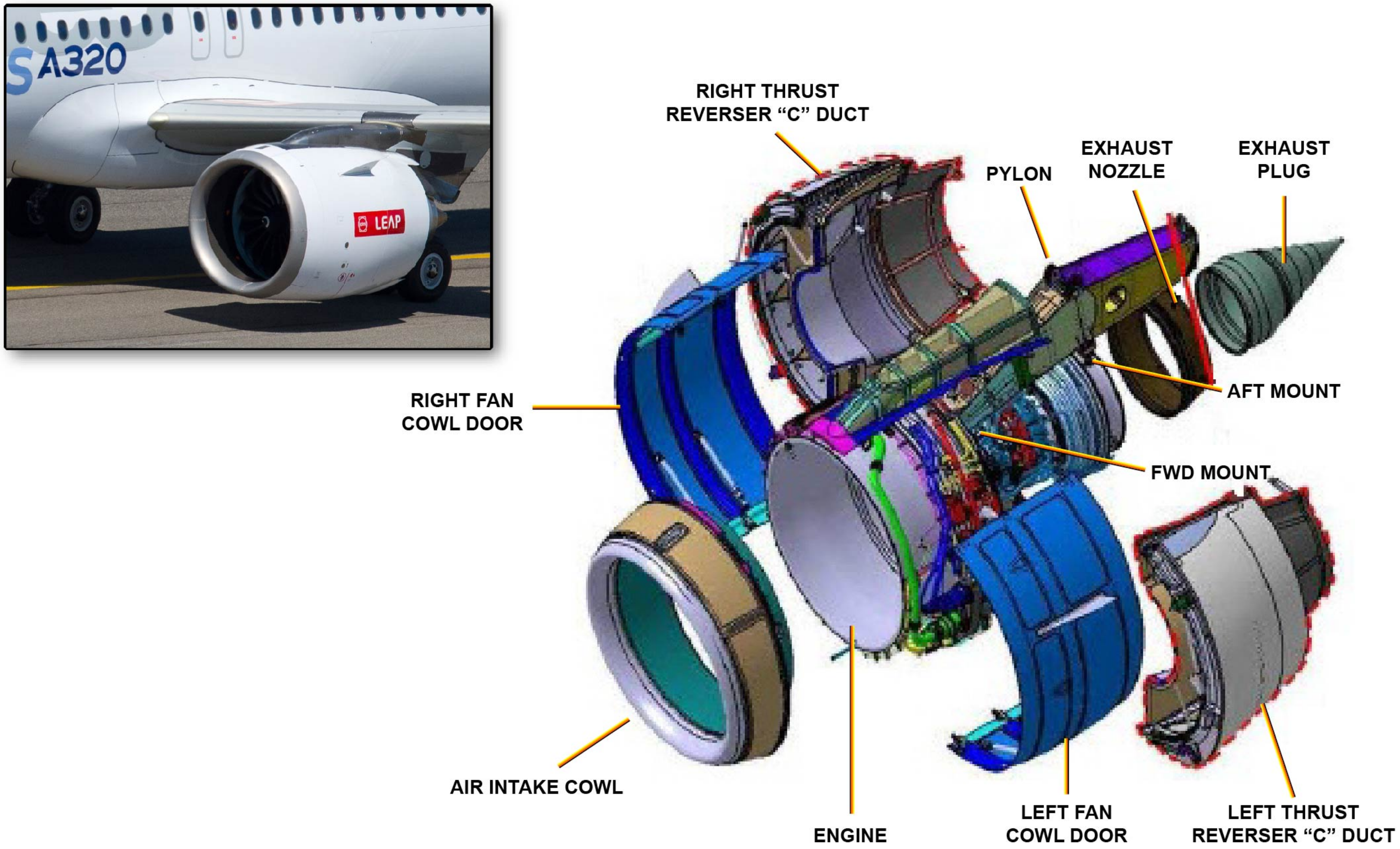
UNDER NO CIRCUMSTANCES SHALL PRESERVATIVE OIL OR EQUIVALENT BE SPRAYED INTO THE ENGINE INLET, CORE COMPRESSOR OR TURBINE, OR ENGINE EXHAUST. DIRT PARTICLES DEPOSITED ON THE WET BLADES AND VANES MAY ADVERSELY AFFECT ENGINE PERFORMANCE DURING SUBSEQUENT OPERATION.

STORAGE AND PRESERVATION

POWER PLANT SYSTEM COMPONENT LOCATION (LEAP)

SYSTEM OVERVIEW

The LEAP-1A engine is a dual-rotor, variable stator, high-bypass-ratio turbo-fan power plant. The LEAP-1A can power the A319, A320 and A321 aircrafts of the Single Aisle family with in the adapted thrust ratings. The power plant installation includes the engine, the engine inlet, the exhaust, the fan cowls and the reverser assemblies. The pylon connects the engine to the wing structure. The engine is attached to the pylon by forward and aft mounts.


A320
LEAP
RIGHT THRUST REVERSER “C” DUCT
PYLON
EXHAUST NOZZLE
EXHAUST PLUG
RIGHT FAN COWL DOOR
AFT MOUNT
FWD MOUNT
AIR INTAKE COWL
ENGINE
LEFT FAN COWL DOOR
LEFT THRUST REVERSER “C” DUCT

SYSTEM OVERVIEW

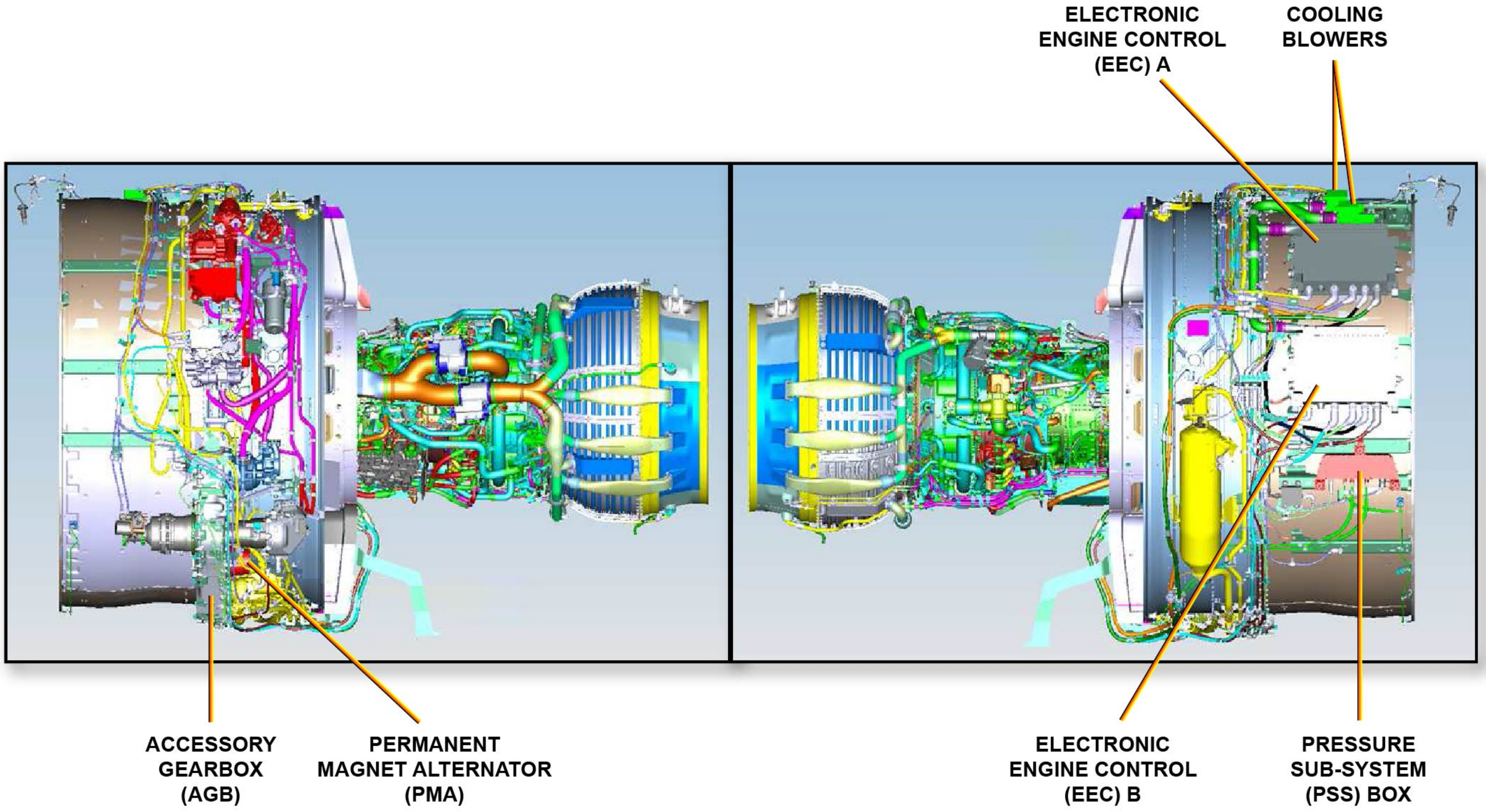
POWER PLANT SYSTEM COMPONENT LOCATION (LEAP)

COMPONENT LOCATION

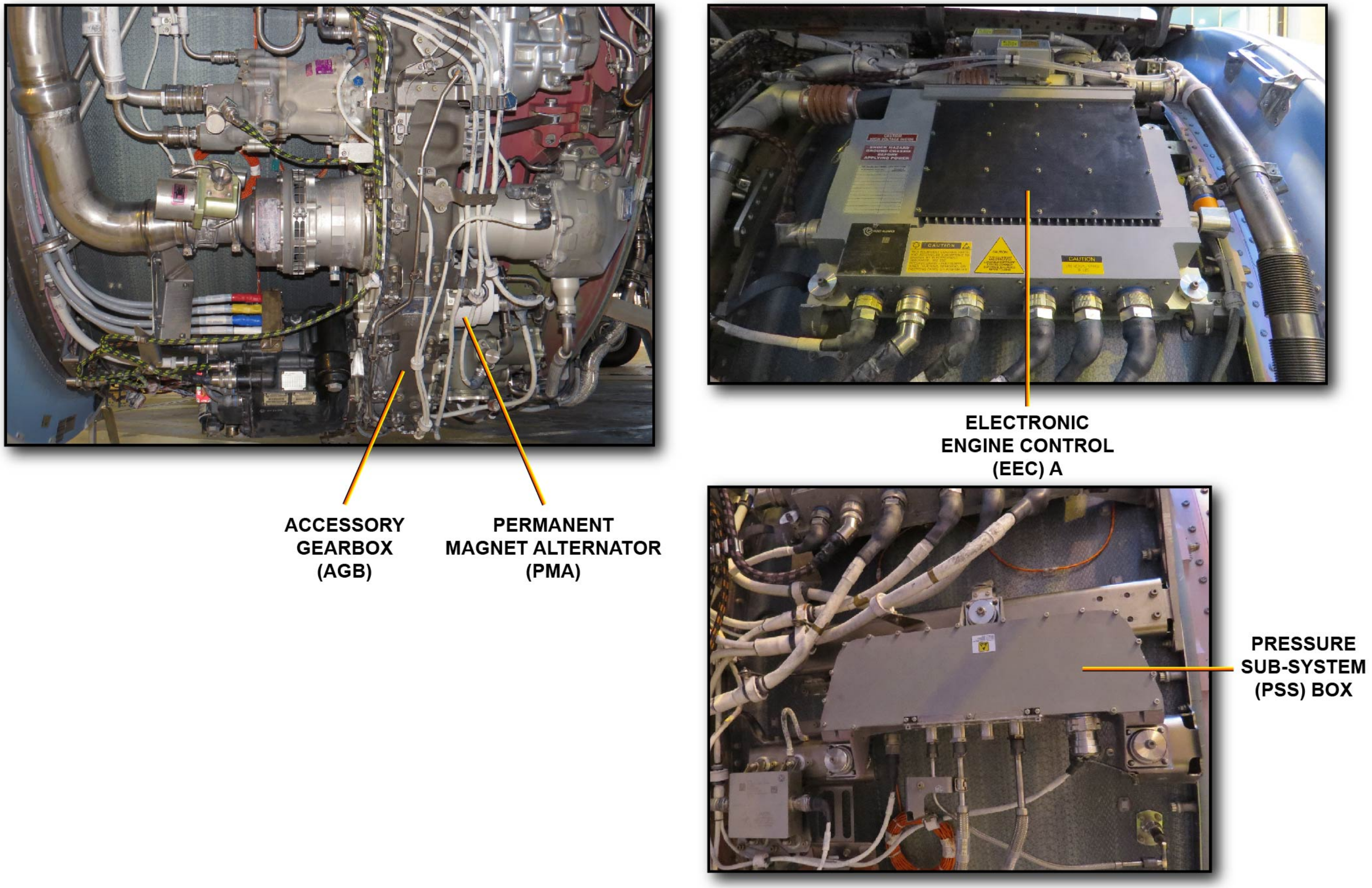
The engine system components are at the following locations.

FADEC

Both Electronic Engine Controls (EECs) A &B are installed on the RH side of the fan case.
The Full Authority Digital Engine Control (FADEC) - Permanent Magnet Alternator (PMA) is on the LH side of the fan compartment, on the rear face of the gearbox.
The Pressure Sub-System (PSS) box is installed on the RH side of the fan case below the EEC B.
The rating plug on the PSS box changes the available thrust.
The two EEC cooling blowers are installed on the RH side of the fan case above the EEC A.


ELECTRONIC ENGINE CONTROL (EEC) A
COOLING BLOWERS
ACCESSORY GEARBOX (AGB)
PERMANENT MAGNET ALTERNATOR (PMA)
ELECTRONIC ENGINE CONTROL (EEC) B
PRESSURE SUB-SYSTEM (PSS) BOX

COMPONENT LOCATION - FADEC


ACCESSORY GEARBOX (AGB)
PERMANENT MAGNET ALTERNATOR (PMA)
ELECTRONIC ENGINE CONTROL (EEC) A
PRESSURE SUB-SYSTEM (PSS) BOX

COMPONENT LOCATION - FADEC

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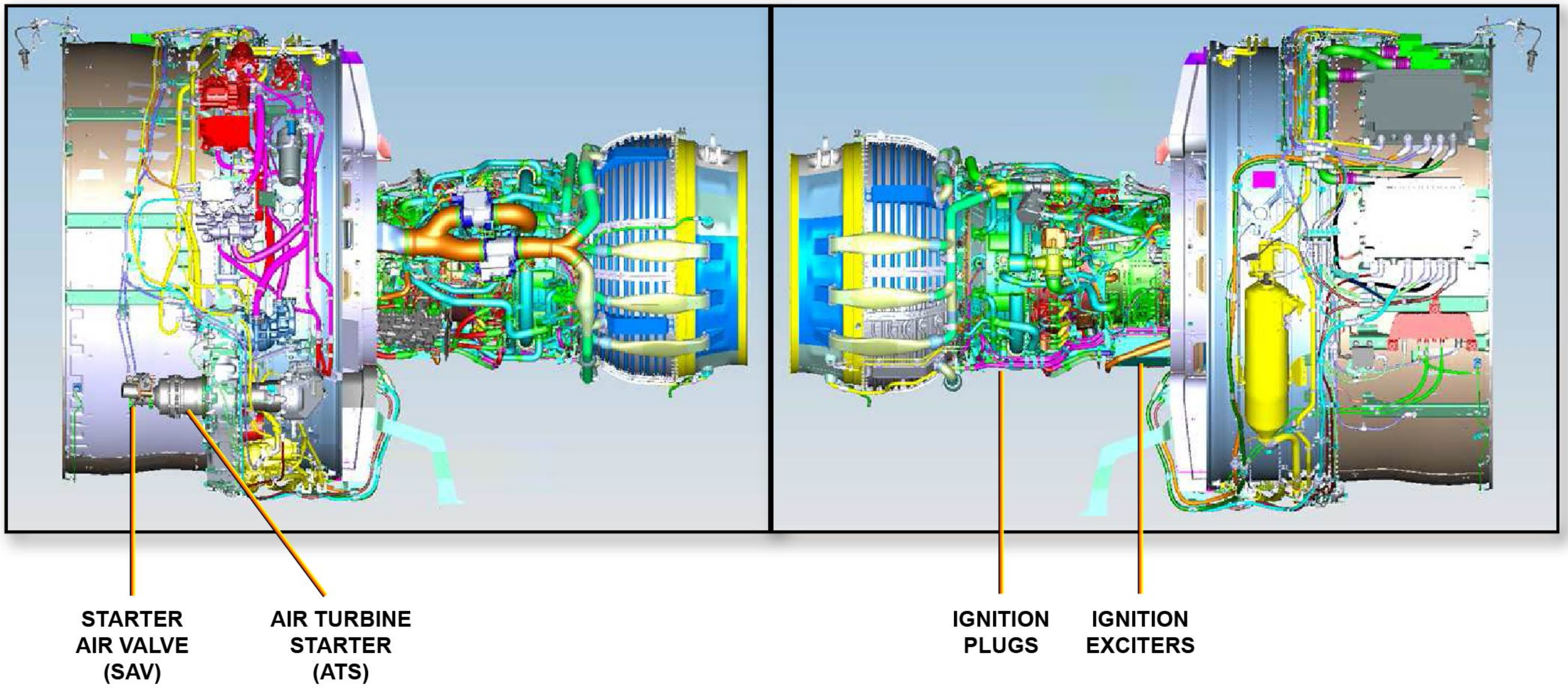
POWER PLANT SYSTEM COMPONENT LOCATION (LEAP)

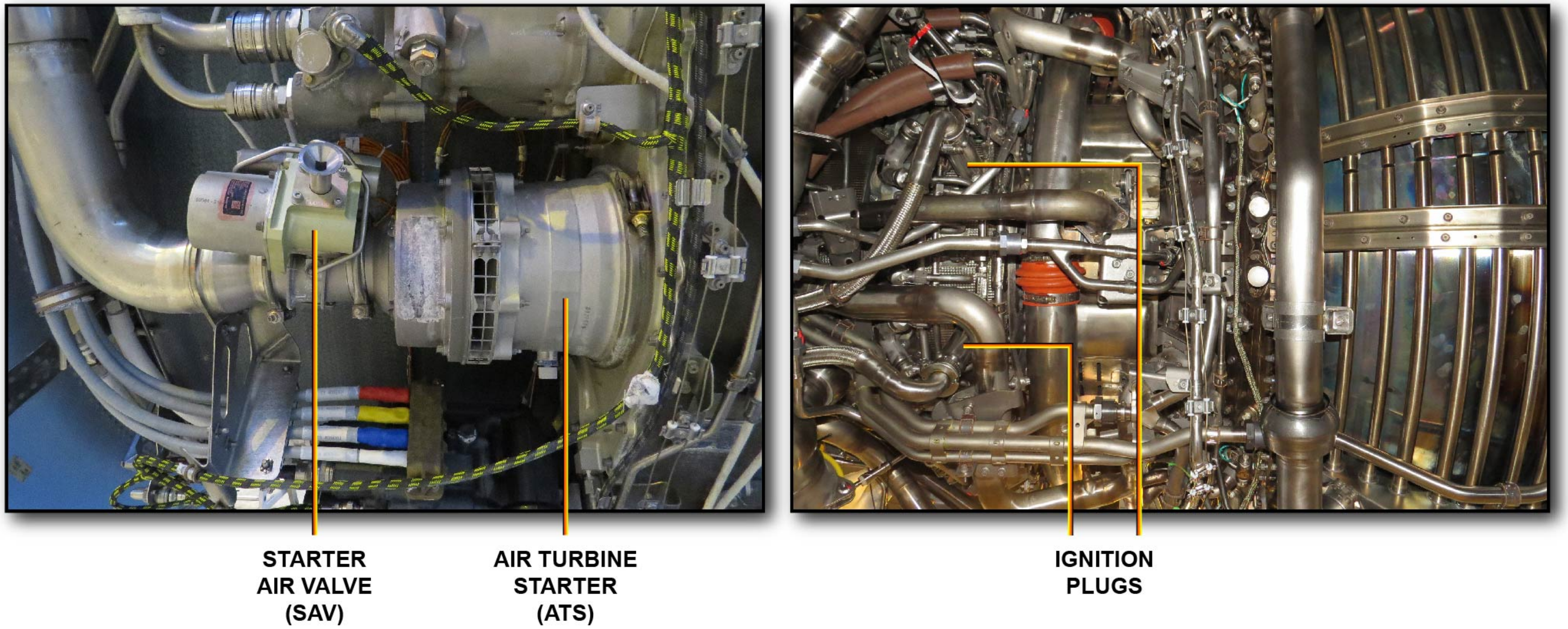
COMPONENT LOCATION (continued)

IGNITION & STARTING

The two ignition exciters are at 6 o'clock position, on the HP compressor case.
The two igniter plugs are installed on the combustor case at 5 and 7 o'clock position.
The Air Turbine Starter (ATS) is located on the LH side of the fan compartment, on the front face of the gearbox.
The Starter Air Valve (SAV) is fitted on the ATS.


STARTER AIR VALVE (SAV)
AIR TURBINE STARTER (ATS)
IGNITION PLUGS
IGNITION EXCITERS

COMPONENT LOCATION - IGNITION & STARTING


STARTER AIR VALVE (SAV)
AIR TURBINE STARTER (ATS)
IGNITION PLUGS

COMPONENT LOCATION - IGNITION & STARTING

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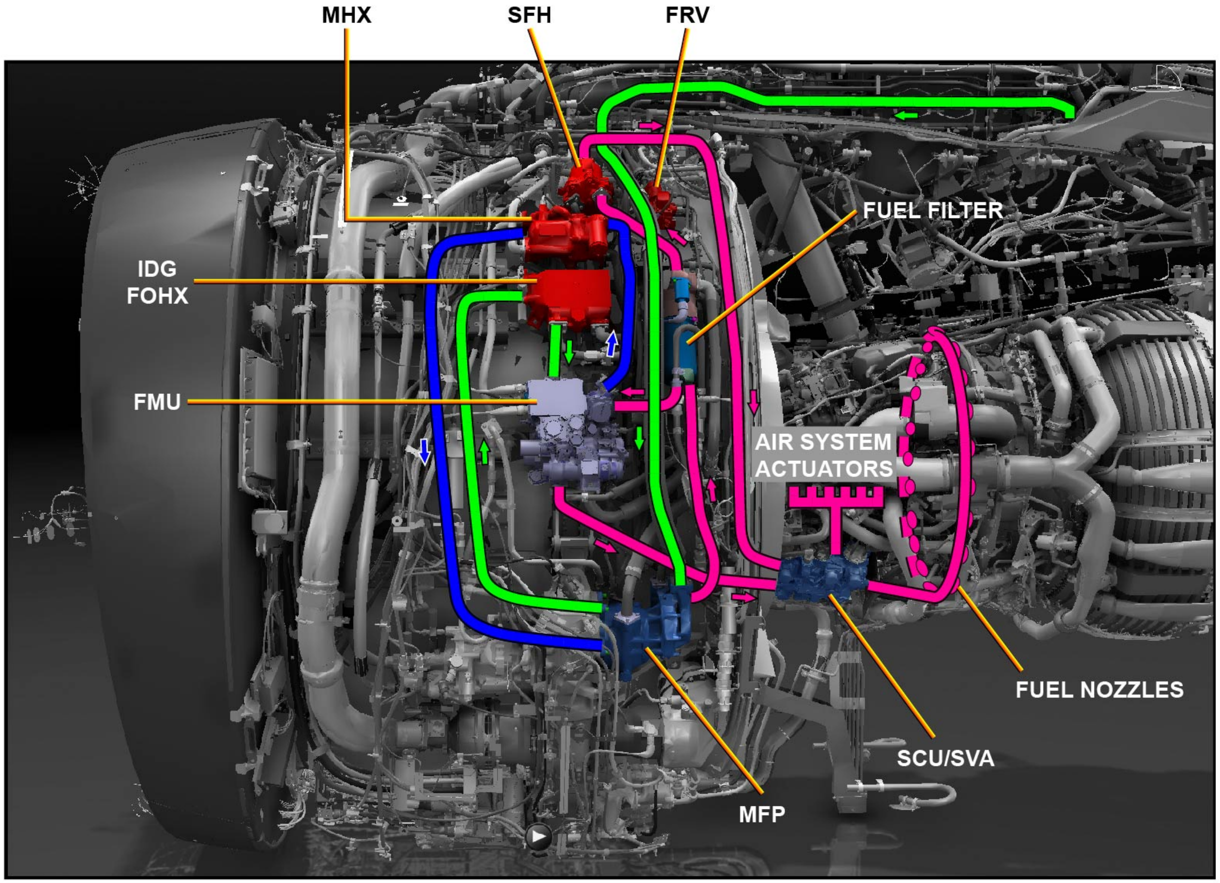
POWER PLANT SYSTEM COMPONENT LOCATION (LEAP)

COMPONENT LOCATION (continued)

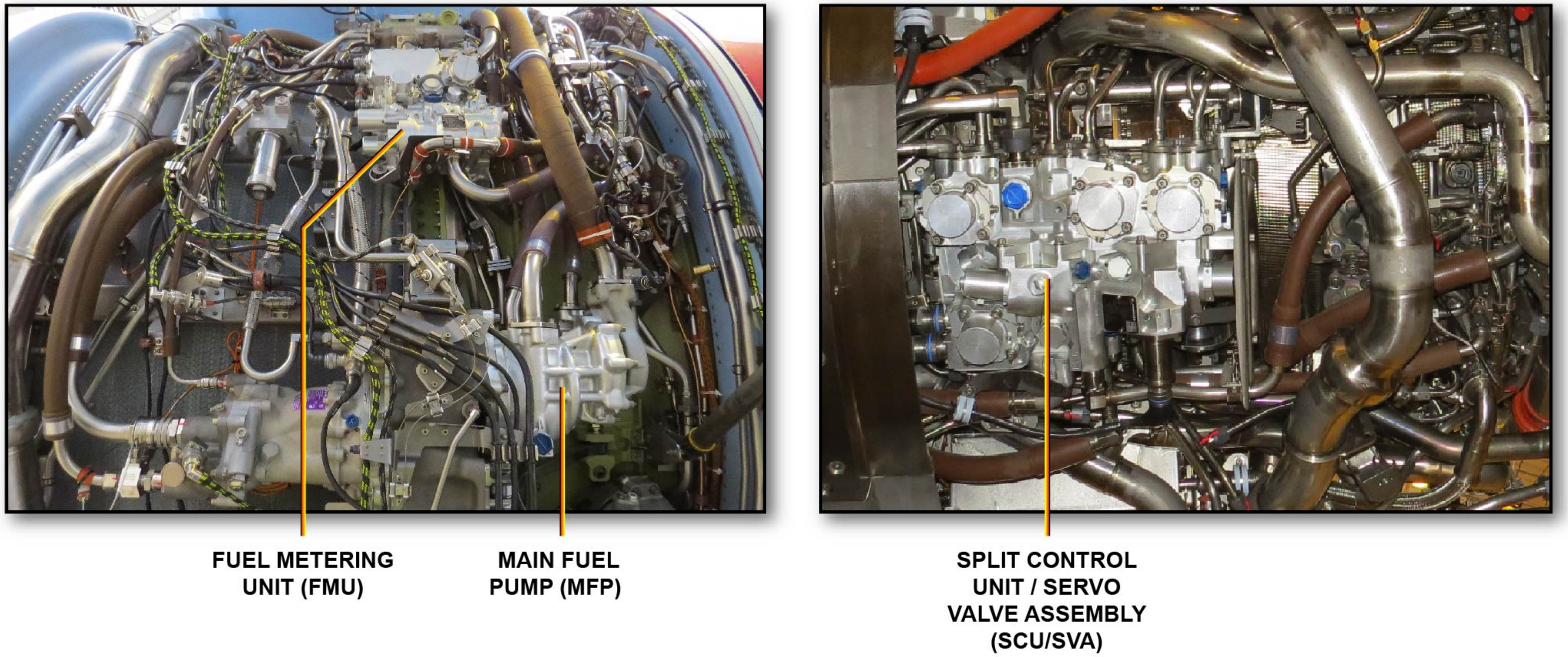
FUEL

The majority of the fuel system components are installed on the LH side of the fan case.
The Main Fuel Pump (MFP) is installed on the LH side of the fan compartment, on the rear face of the gearbox.
The Fuel Metering Unit (FMU), Main Heat Exchanger (MHX), IDG Fuel Oil Heat Exchanger (IDGFOHX), Servo Fuel Heater (SFH), Fuel Return Valve (FRV) and Fuel Filter (FF) are located above the accessory gearbox on the LH side of the fan case.
The Split Control Unit/Servo Valve Assembly (SCU/SVA) is installed on the LH side of the HP compressor case at 7 o'clock position.
The fuel nozzles are fitted around the combustion chamber.


MHX
SFH
FRV
FUEL FILTER
IDG
FOHX
FMU
AIR SYSTEM
ACTUATORS
FUEL NOZZLES
SCU/SVA
MFP

FMU: Fuel Metering Unit	**MFP: Main Fuel Pump**
FOHX: Fuel Oil Heat Exchanger	**MHX: Main Heat Exchanger**
FRV: Fuel Return Valve	**SCU/SVA: Split Control Unit/Servo Valve Assembly**
IDG: Integrated Drive Generator	**SFH: Servo Fuel Heater**

COMPONENT LOCATION - FUEL


FUEL METERING UNIT (FMU)
MAIN FUEL PUMP (MFP)
SPLIT CONTROL UNIT / SERVO VALVE ASSEMBLY (SCU/SVA)

COMPONENT LOCATION - FUEL

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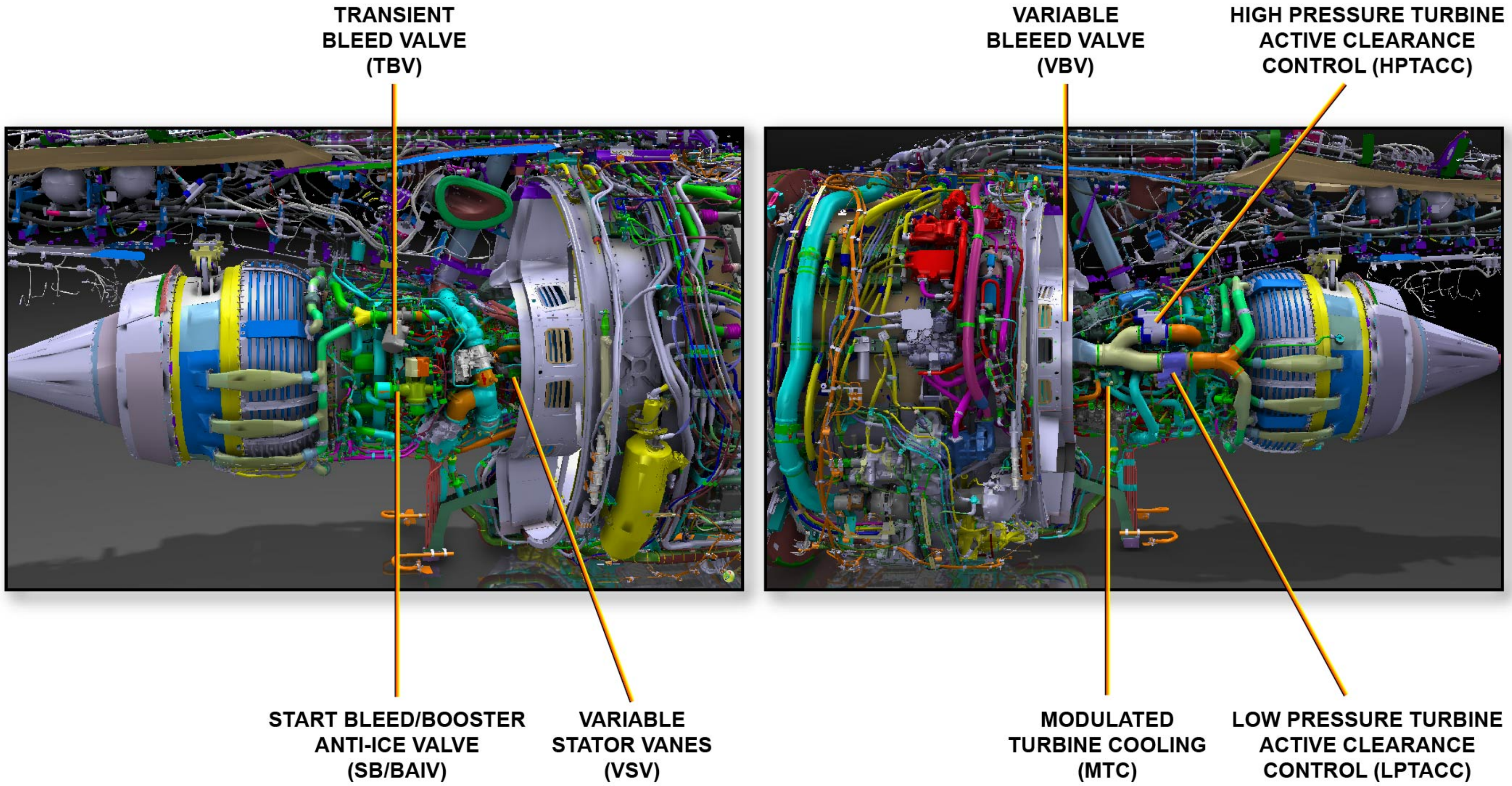
POWER PLANT SYSTEM COMPONENT LOCATION (LEAP)

COMPONENT LOCATION (continued)

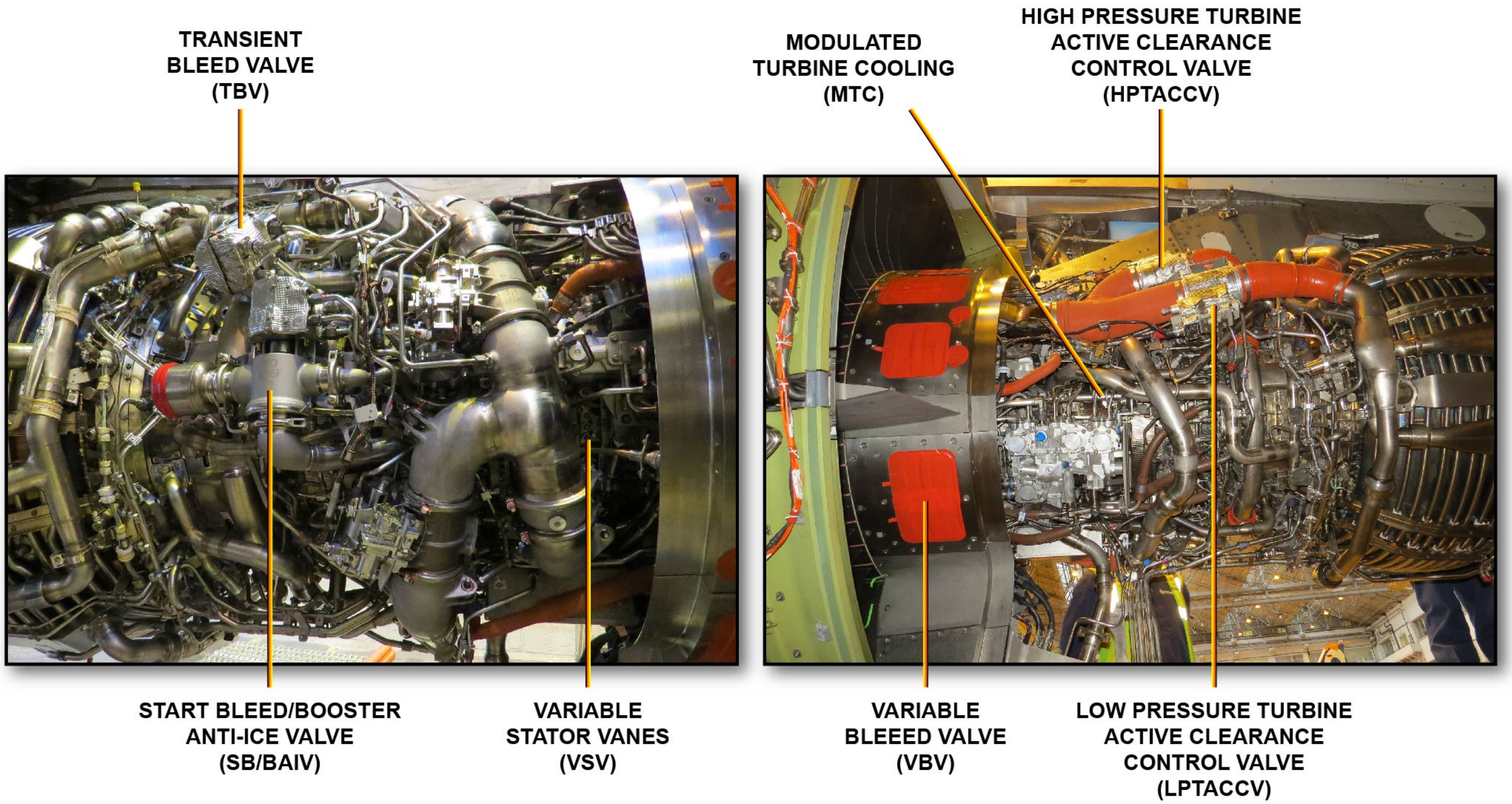
AIR

The air system comprises several sub-systems:
- to manage the compressor airflow (Variable Bleed Valves (VBV), Variable Stator Vanes (VSV), Start Bleed/Booster Anti Ice (SB/BAI), Transient Bleed Valve (TBV)) and
- to cool some turbine parts (LP Turbine Active Clearance Control (TACC), HPTACC, Modulated Turbine Cooling (MTC)).

All the major components are installed at the booster discharge and around the engine core.


TRANSIENT BLEED VALVE (TBV)
VARIABLE BLEEED VALVE (VBV)
HIGH PRESSURE TURBINE ACTIVE CLEARANCE CONTROL (HPTACC)
START BLEED/BOOSTER ANTI-ICE VALVE (SB/BAIV)
VARIABLE STATOR VANES (VSV)
MODULATED TURBINE COOLING (MTC)
LOW PRESSURE TURBINE ACTIVE CLEARANCE CONTROL (LPTACC)

COMPONENT LOCATION - AIR


TRANSIENT BLEED VALVE (TBV)
MODULATED TURBINE COOLING (MTC)
HIGH PRESSURE TURBINE ACTIVE CLEARANCE CONTROL VALVE (HPTACCV)
START BLEED/BOOSTER ANTI-ICE VALVE (SB/BAIV)
VARIABLE STATOR VANES (VSV)
VARIABLE BLEEED VALVE (VBV)
LOW PRESSURE TURBINE ACTIVE CLEARANCE CONTROL VALVE (LPTACCV)

COMPONENT LOCATION - AIR

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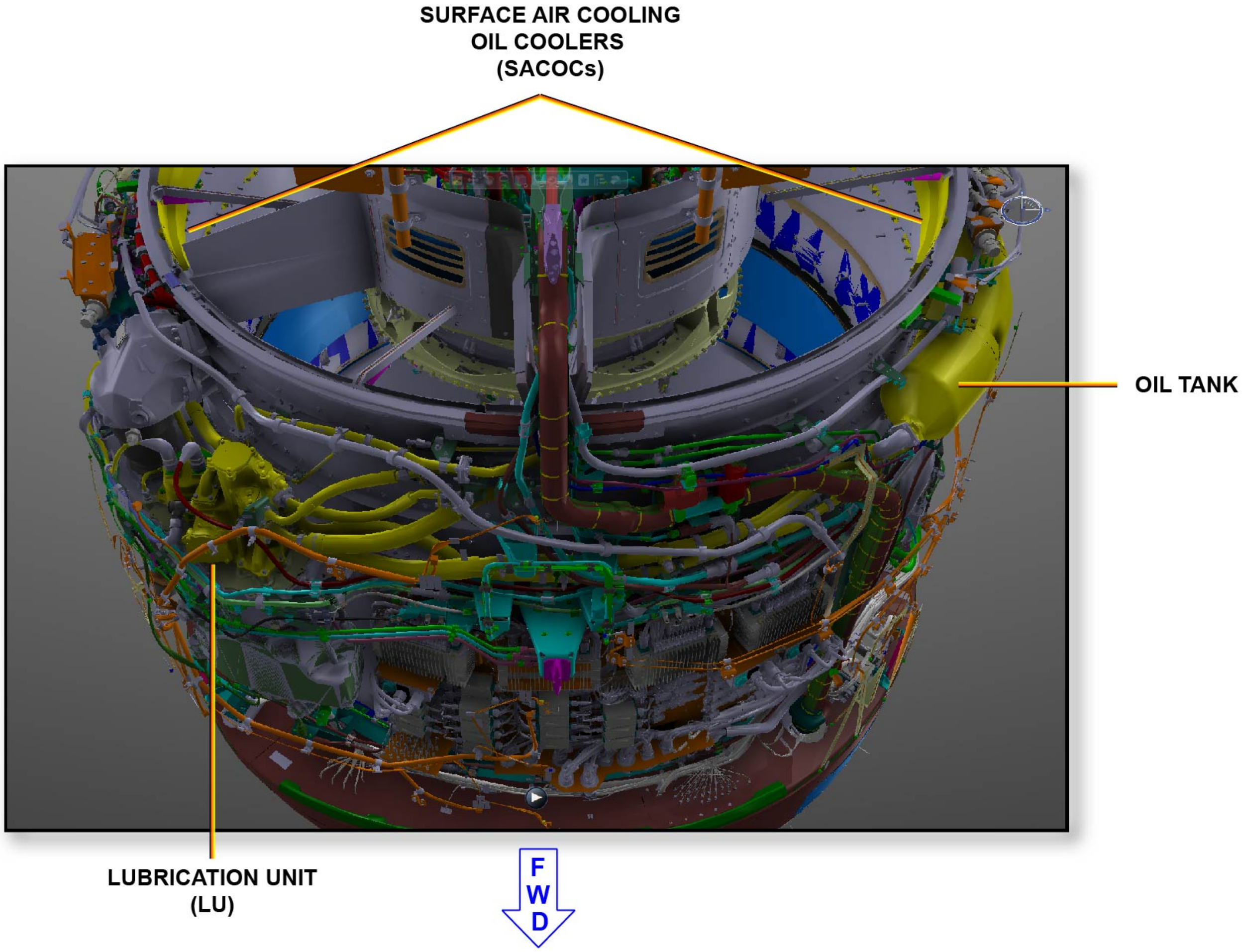
POWER PLANT SYSTEM COMPONENT LOCATION (LEAP)

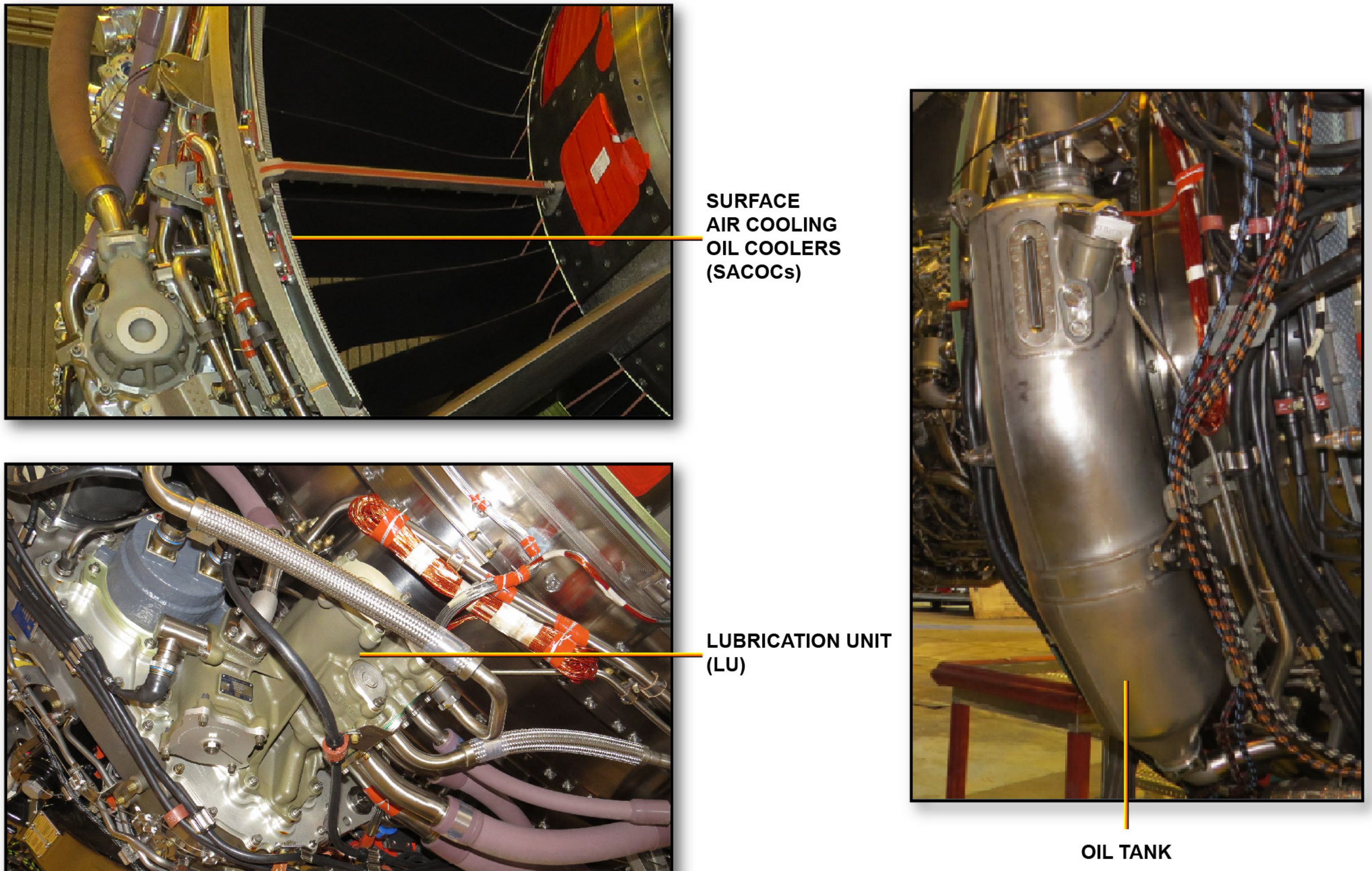
COMPONENT LOCATION (continued)

OIL

The oil tank is installed on the RH side of the fan case at 4 o'clock position.
The Lubrication Unit (LU) is installed on the LH side of the fan compartment, on the rear face of the gearbox.
The Oil Filter is fitted inside the LU.
The Surface Air Cooling Oil Coolers (SACOCs) are installed on the inner surface of the Fan Frame after the fan discharge vanes.


SURFACE AIR COOLING OIL COOLERS (SACOCs)
OIL TANK
LUBRICATION UNIT (LU)
FWD

COMPONENT LOCATION - OIL


SURFACE
AIR COOLING
OIL COOLERS
(SACOCs)
LUBRICATION UNIT
(LU)
OIL TANK

COMPONENT LOCATION - OIL

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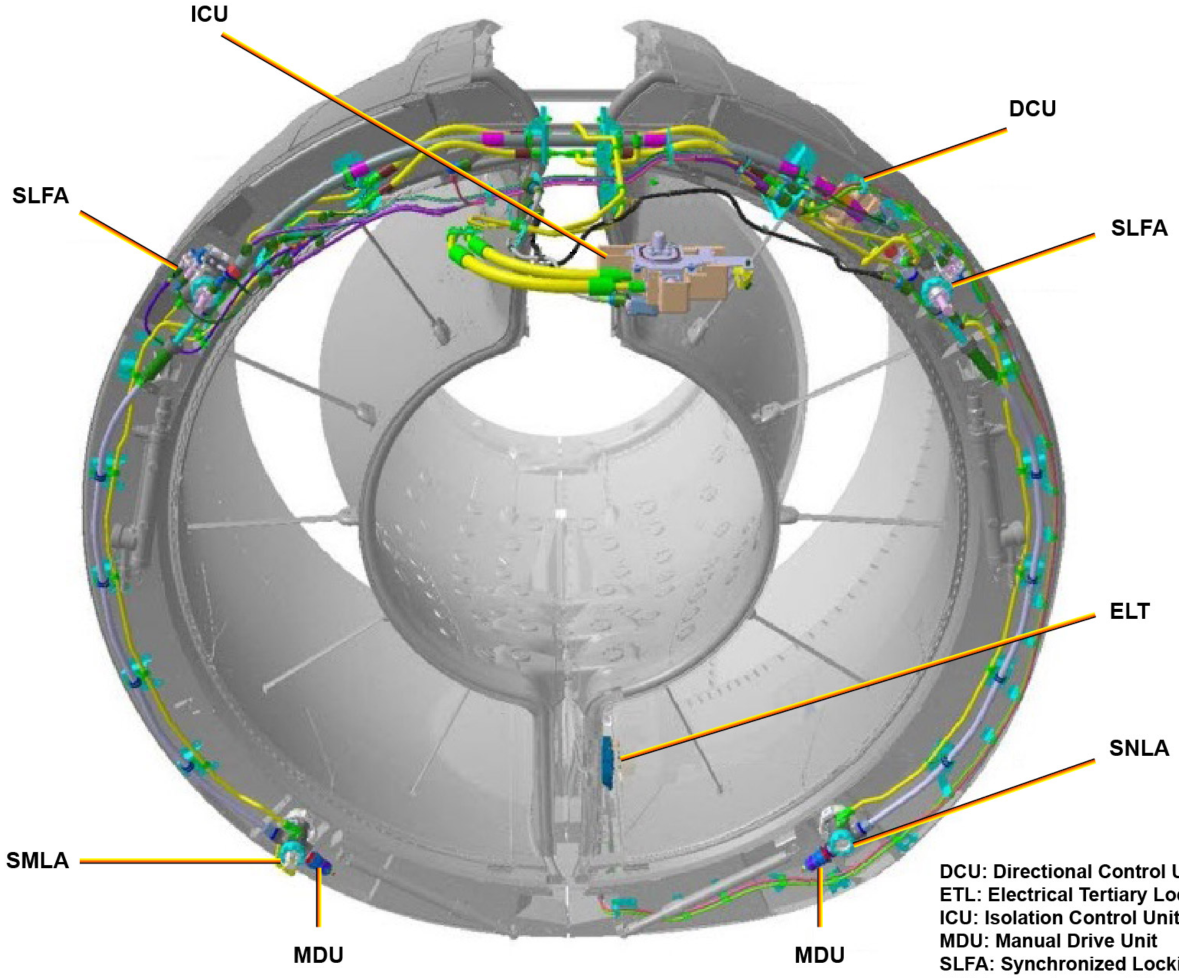
POWER PLANT SYSTEM COMPONENT LOCATION (LEAP)

COMPONENT LOCATION (continued)

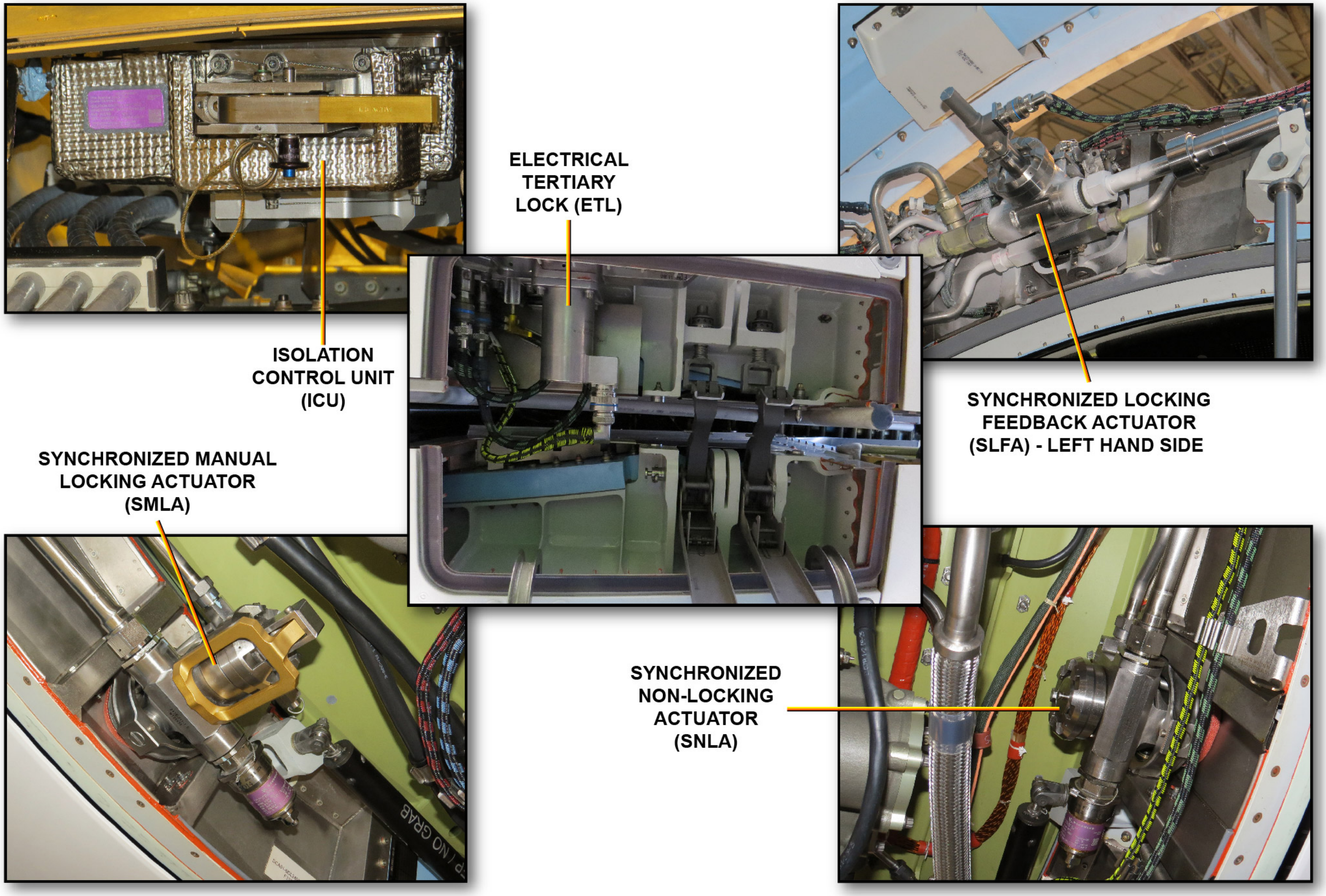
THRUST REVERSER

The Isolation Control Unit (ICU) is attached to pylon floor, in fan compartment.
The Directional Control Unit (DCU) is installed on the upper part of the LH fan case.
The Synchronized Locking Feedback Actuators (SLFAs) are installed at 11 and 1 o'clock position of the Thrust Reverser (TR) forward frame.
The Synchronized Non-Locking Actuator (SNLA) is installed at the bottom of the LH TR forward frame
The Synchronized Manual Locking Actuator (SMLA) is installed at the bottom of the RH TR forward frame.
The Electrical Tertiary Lock (ETL) is attached to LH TR beam at 6 o'clock position.
The Manual Drive Units (MDUs) are fitted on the lower actuators.



DCU: Directional Control Unit
ETL: Electrical Tertiary Lock
ICU: Isolation Control Unit
MDU: Manual Drive Unit
SLFA: Synchronized Locking Feedback Actuator
SMLA: Synchronized Manual Locking Actuator
SNLA: Synchronized Non-Locking Actuator

COMPONENT LOCATION - THRUST REVERSER


ELECTRICAL TERTIARY LOCK (ETL)
ISOLATION CONTROL UNIT (ICU)
SYNCHRONIZED LOCKING FEEDBACK ACTUATOR (SLFA) - LEFT HAND SIDE
SYNCHRONIZED MANUAL LOCKING ACTUATOR (SMLA)
SYNCHRONIZED NON-LOCKING ACTUATOR (SNLA)

COMPONENT LOCATION - THRUST REVERSER

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ENGINE SYSTEM CONTROL AND INDICATING (2) - CFM LEAP1A

Engine Systems - General (2)

FADEC Powering and Depowering (2)

Engine Parameters Display (2)

Engine Fuel System Contamination (2)

Thrust Reverser inhibited (2)

Fan Cowl not closed (2)

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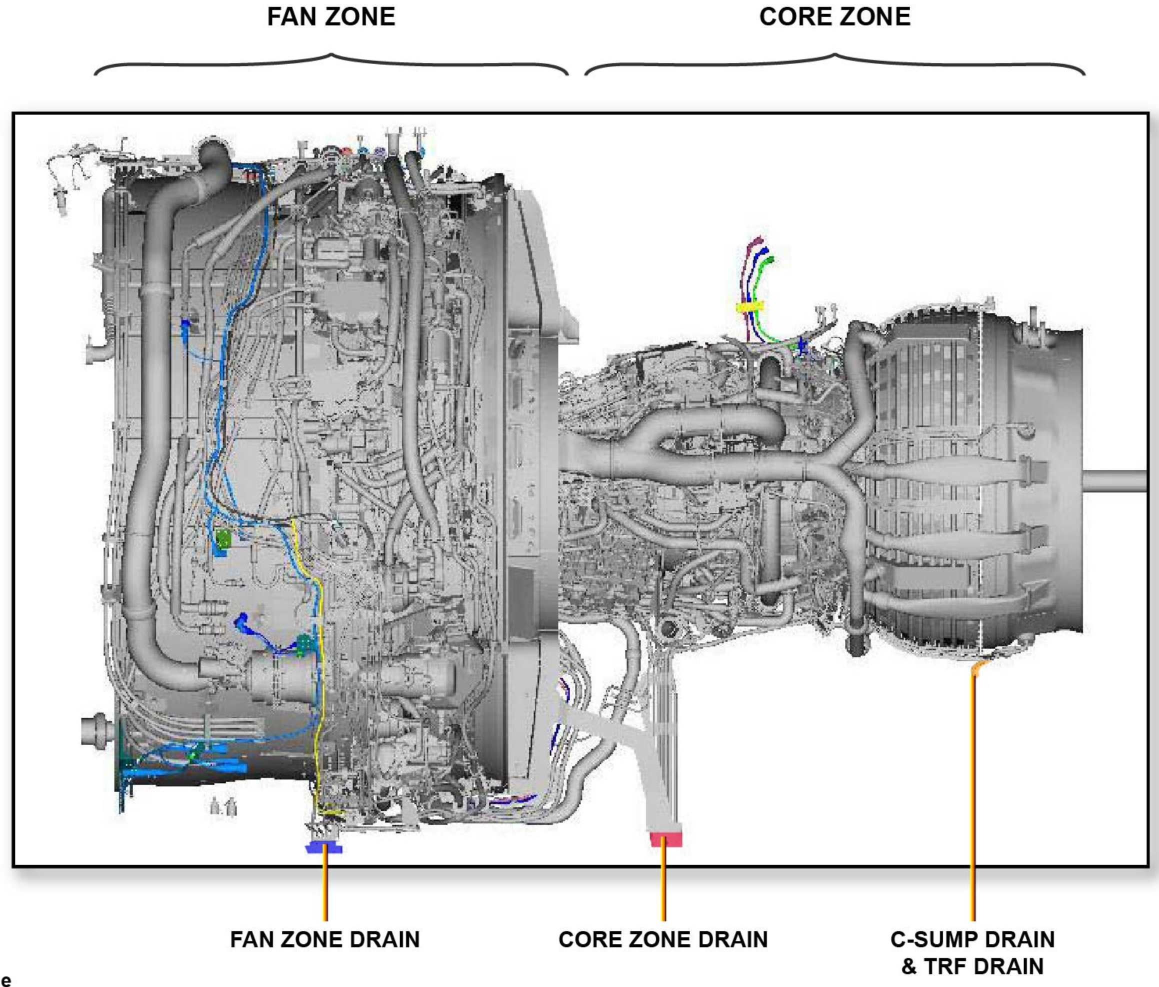
POWER PLANT DRAIN PRESENTATION

PYLON & ENGINE DRAINS

The drains from the engine and pylon exit the nacelle through two drain masts and two drain tubes: The fan zone drain mast, the core zone drain mast and the rear drain tubes.
The drain system provides a controlled leak path exit to the 6 o'clock position of the nacelle for hydraulic, oil and fuel systems.
Drain lines are designed to drain all excess system fluids accumulated in both pylon, the fan and core zones. The drain system is designed such that each drain line outlet is dedicated to only one drain, with the exception of the core equipment drain lines where combined drains are used. The drain masts are removable without disconnection of the drain lines.
The C-sump & Turbine Rear Frame (TRF) drain tubes, on the rear of the core, are respectively used for oil and water/fuel drainage.


FAN ZONE
CORE ZONE
FAN ZONE DRAIN
CORE ZONE DRAIN
C-SUMP DRAIN
& TRF DRAIN

TRF: Turbine Rear Frame

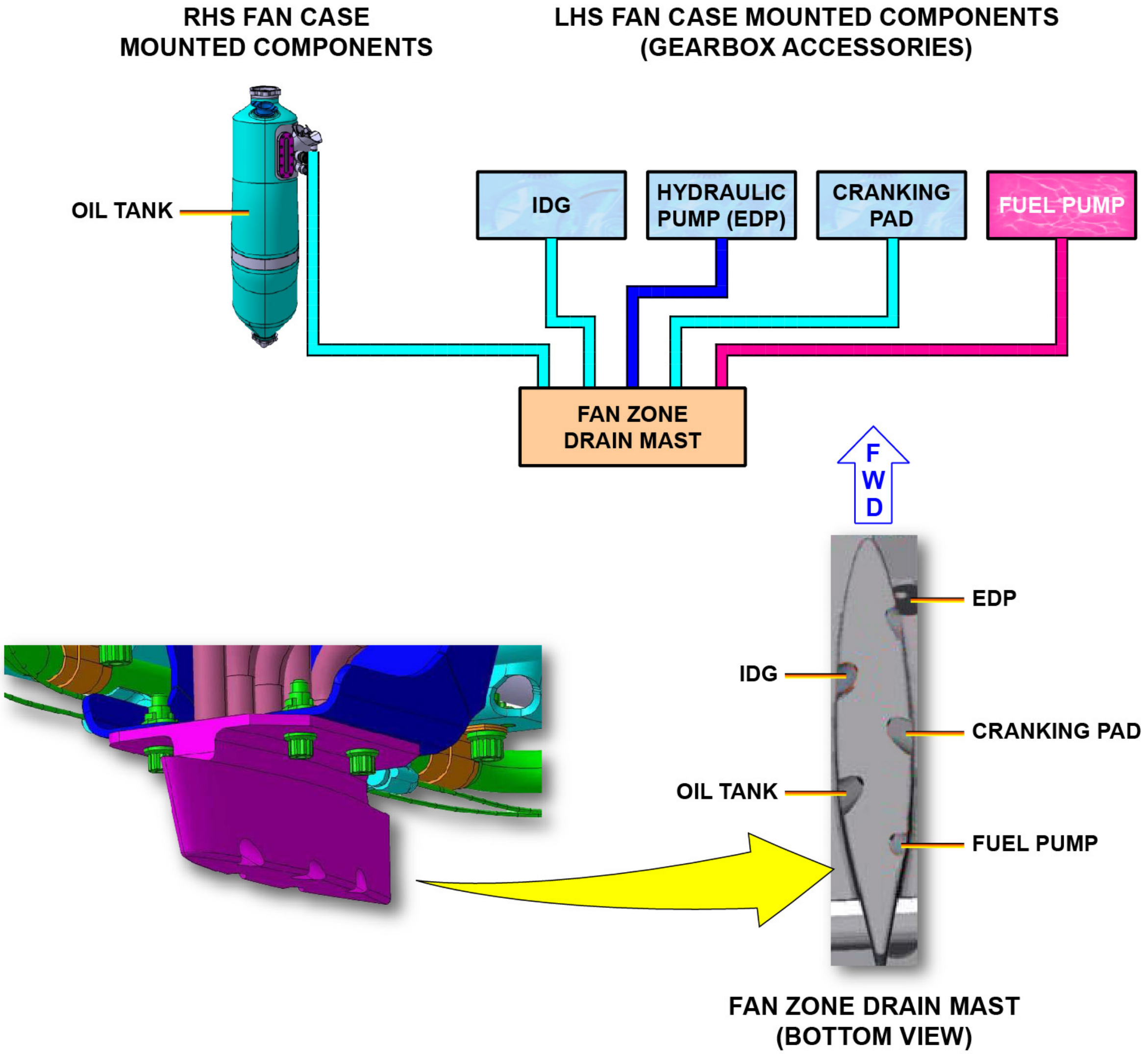
PYLON & ENGINE DRAINS

POWER PLANT DRAIN PRESENTATION

FAN ZONE DRAIN MAST

At the 6 o'clock position the aerodynamic forward drain mast internally connects 5 drain tubes and protrudes below the nacelle surface. The FWD drain mast has 5 exit holes on the sides and bottom surface which are identified to enable trouble shooting of the leaking components.

🟪 **FUEL DRAIN**
🟦 **LUBE DRAIN**
🟦 **HYDRAULIC DRAIN**


RHS FAN CASE
MOUNTED COMPONENTS
LHS FAN CASE MOUNTED COMPONENTS
(GEARBOX ACCESSORIES)
OIL TANK
IDG
HYDRAULIC PUMP (EDP)
CRANKING PAD
FUEL PUMP
FAN ZONE DRAIN MAST
FWD
EDP
IDG
CRANKING PAD
OIL TANK
FUEL PUMP
FAN ZONE DRAIN MAST
(BOTTOM VIEW)

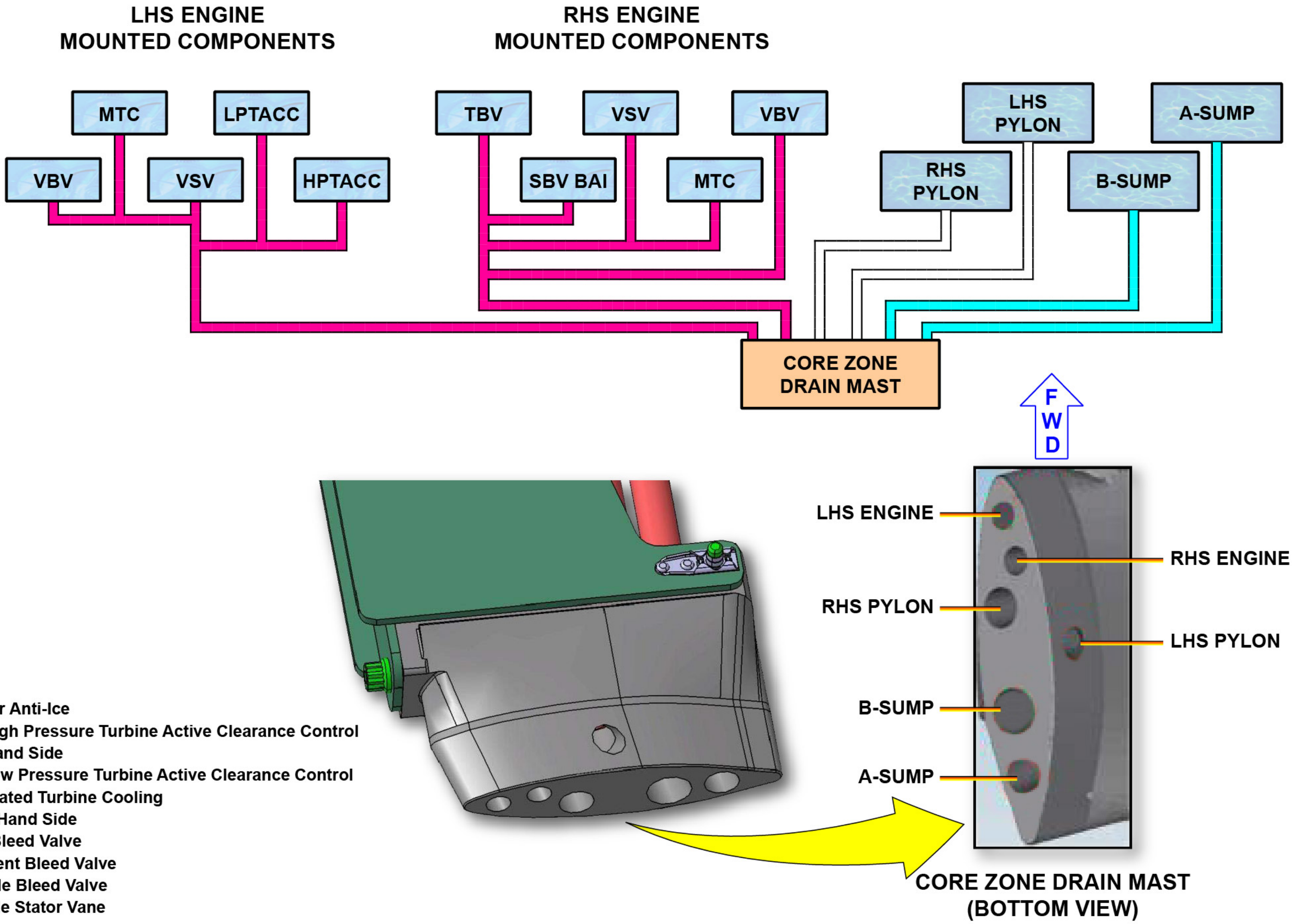
EDP: Engine Driven Pump
IDG: Integrated Drive Generator
LHS: Left Hand Side
RHS: Right Hand Side

FAN ZONE DRAIN MAST

POWER PLANT DRAIN PRESENTATION

CORE ZONE DRAIN MAST

At the 6 o'clock position the aerodynamic aft drain mast internally connects 6 main drain tubes and protrudes below the nacelle surface. The drain mast has 6 exit holes on the sides and bottom surface which are identified to enable trouble shooting of the leaking components.


LHS ENGINE
MOUNTED COMPONENTS
RHS ENGINE
MOUNTED COMPONENTS
MTC
LPTACC
VBV
VSV
HPTACC
TBV
VSV
VBV
SBV BAI
MTC
LHS PYLON
A-SUMP
RHS PYLON
B-SUMP
CORE ZONE DRAIN MAST
FWD
LHS ENGINE
RHS ENGINE
RHS PYLON
LHS PYLON
B-SUMP
A-SUMP
CORE ZONE DRAIN MAST
(BOTTOM VIEW)

BAI: Booster Anti-Ice
HPTACC: High Pressure Turbine Active Clearance Control
LHS: Left Hand Side
LPTACC: Low Pressure Turbine Active Clearance Control
MTC: Modulated Turbine Cooling
RHS: Right Hand Side
SBV: Start Bleed Valve
TBV: Transient Bleed Valve
VBV: Variable Bleed Valve
VSV: Variable Stator Vane

CORE ZONE DRAIN MAST

POWER PLANT INSTALLATION D/O

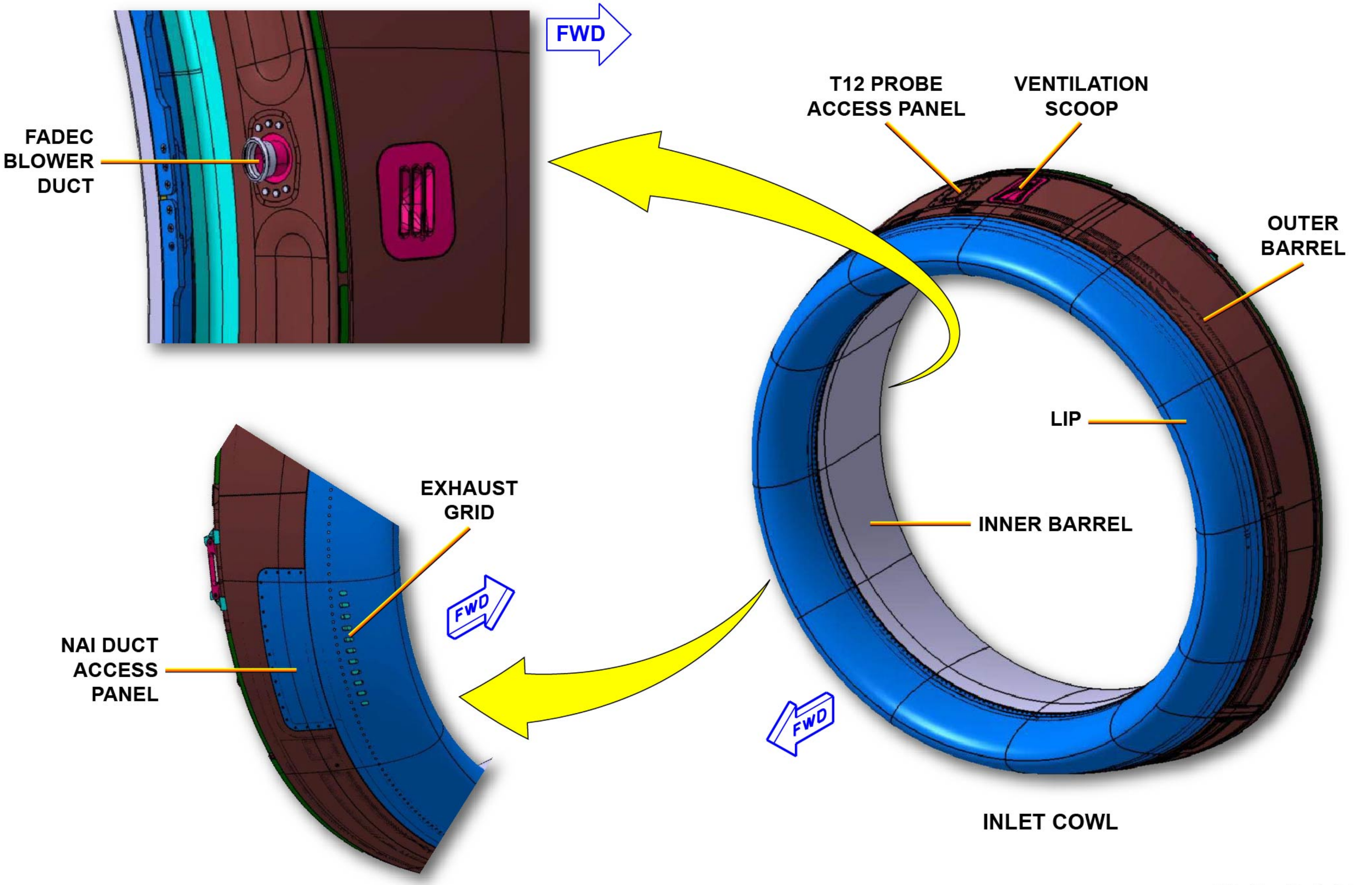
INLET COWL

The air intake or inlet cowl is an interchangeable aerodynamic component installed at the front of the engine.
It is composed of an inner barrel, an outer barrel integrating a hybrid aft bulkhead, an attachment ring, a forward titanium bulkhead and a nose lip. The inner barrel is a one-piece composite acoustic panel. It accommodates the T12 probe at the 1 o'clock position.
The outer barrel is made of three composite segments attached by splices.
It comprises:
- a ventilation scoop located at the 12 o'clock position to provide ram air for the fan compartment cooling,
- a T12 probe access panel at the 1 o'clock position,
- a FADEC blower inlet grid and duct at the 3 o'clock position,
- a Nacelle Anti Ice (NAI) duct access panel and a NAI exhaust grid at the 4 o'clock position.

The forward and aft bulkhead provides support and rigidity to the structure.
The nose lip is made of a single piece aluminium alloy for engine anti-ice purpose.
The inlet cowl is attached to the engine at the attachment ring by 36 sets of standard bolts, nuts and spacers.
The outer barrel is fitted with 4 hoisting points for removal/installation and with 6 holes for the inlet protection cover installation.
The aft bulkhead comprises 4 Fan Cowl Door (FCD) locator brackets.

AIR INTAKE FUNCTIONS

The main function of the inlet cowl is to guide the airflow into the engine inlet and to permit an aerodynamic airflow over the outer surface of the engine.
When the engine anti icing is selected to ON from the cockpit overhead panel, hot bleed air from the engine is ducted to the cowl nose lip to prevent ice build-up. The hot air enters to the inlet lip via a dedicated duct at the 4 o' clock position through the front bulkhead.
The air circulates inside the lip and then discharges overboard through an exhaust grid on the outside of the lip.
The outer barrel has an impregnated copper screen layer for protection against lightning strike.


FWD
FADEC BLOWER DUCT
T12 PROBE ACCESS PANEL
VENTILATION SCOOP
OUTER BARREL
LIP
INNER BARREL
EXHAUST GRID
FWD
NAI DUCT ACCESS PANEL
FWD
INLET COWL

NAI: Nacelle Anti-Ice

INLET COWL - AIR INTAKE FUNCTIONS

POWER PLANT INSTALLATION D/O

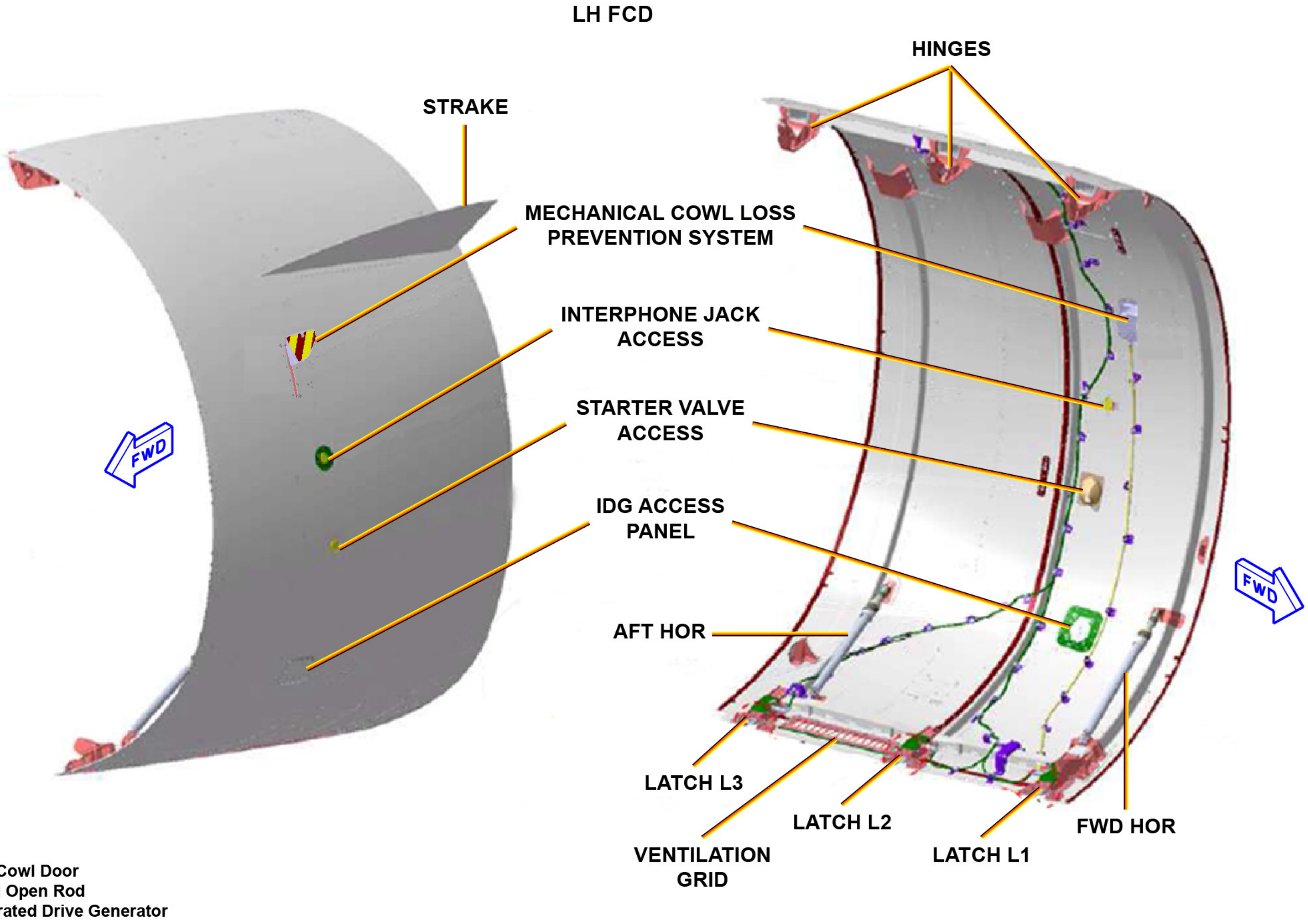
FAN COWL DOORS

There are two FCDs to enclose the fan case, the gear box and to provide aerodynamic smoothness around the engine.
The FCDs are attached to the pylon by three hinges with hinge pins.
The door assembly is latched along the bottom centerline by three latches, named from front to rear: L1, L2 and L3.
One proximity sensor is installed on each latch keeper. They send their position signals to the Engine Interface Unit (EIU) for generating necessary warning.
The latch 1 keeper is fitted with a mechanical Cowl Loss Prevention (CLP) devise. This additional mounting mechanism is linked to a flag, on the LH FCD, via a Teleflex to ensure that it is properly closed.
The door can be opened manually. Each door is provided with 2 telescopic Hold Open Rods (HORs), to secure the opening.
The forward one is permanently connected the fan case and the aft one is stored on the FCD.
Latches opening sequence: L1-L3-L2.
Latches closing sequence: L2-L3-L1.
Each FCD rests on 2 axial locators, when closed. It also has 3 hoist points, for removal/installation.
One aerodynamic strake is mounted on each FCD to improve aircraft performance during maneuvers.
An interphone Jack Flapper Door, on the LH fan cowl, allows access to interphone jack for cockpit/ground communication.
The LH FCD is fitted with:

- an interphone jack access flap door at the 9 o'clock position,
- a starter manual override access flap door located at the 8 o'clock position,
- an Integrated Drive Generator (IDG) access panel located at the 7 o'clock position,
- a ventilation grid at the 6 o'clock position.

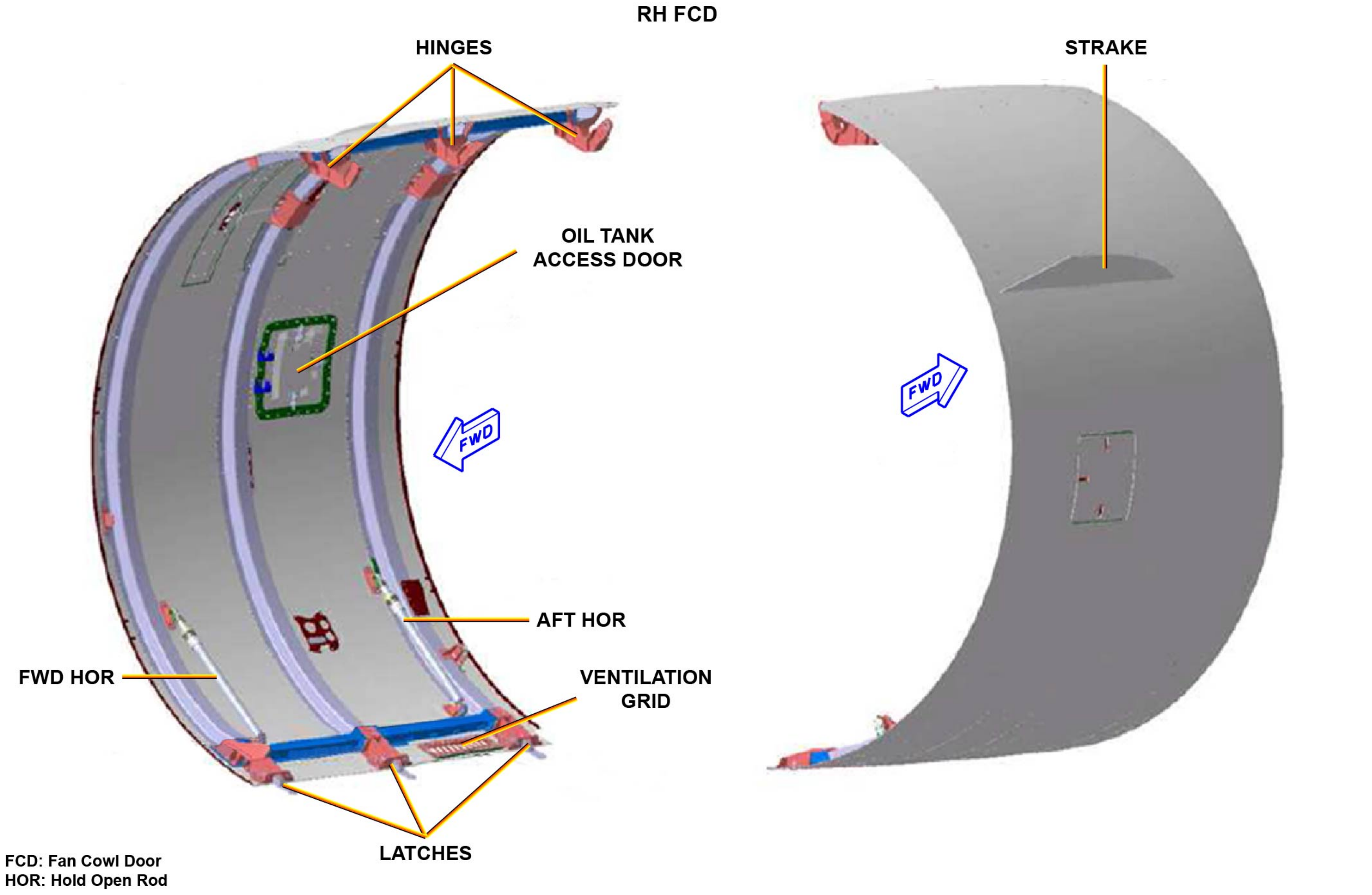
The RH FCD is fitted with:

- an oil tank access door located at the 3 o'clock position,
- a ventilation grid at the 6 o'clock position.


LH FCD
HINGES
STRAKE
MECHANICAL COWL LOSS PREVENTION SYSTEM
INTERPHONE JACK ACCESS
STARTER VALVE ACCESS
IDG ACCESS PANEL
AFT HOR
FWD
FWD
LATCH L3
LATCH L2
LATCH L1
VENTILATION GRID
FWD HOR

FCD: Fan Cowl Door
HOR: Hold Open Rod
IDG: Integrated Drive Generator

FAN COWL DOORS


RH FCD
HINGES
STRAKE
OIL TANK ACCESS DOOR
FWD
FWD
AFT HOR
FWD HOR
VENTILATION GRID
LATCHES
FCD: Fan Cowl Door
HOR: Hold Open Rod

FAN COWL DOORS

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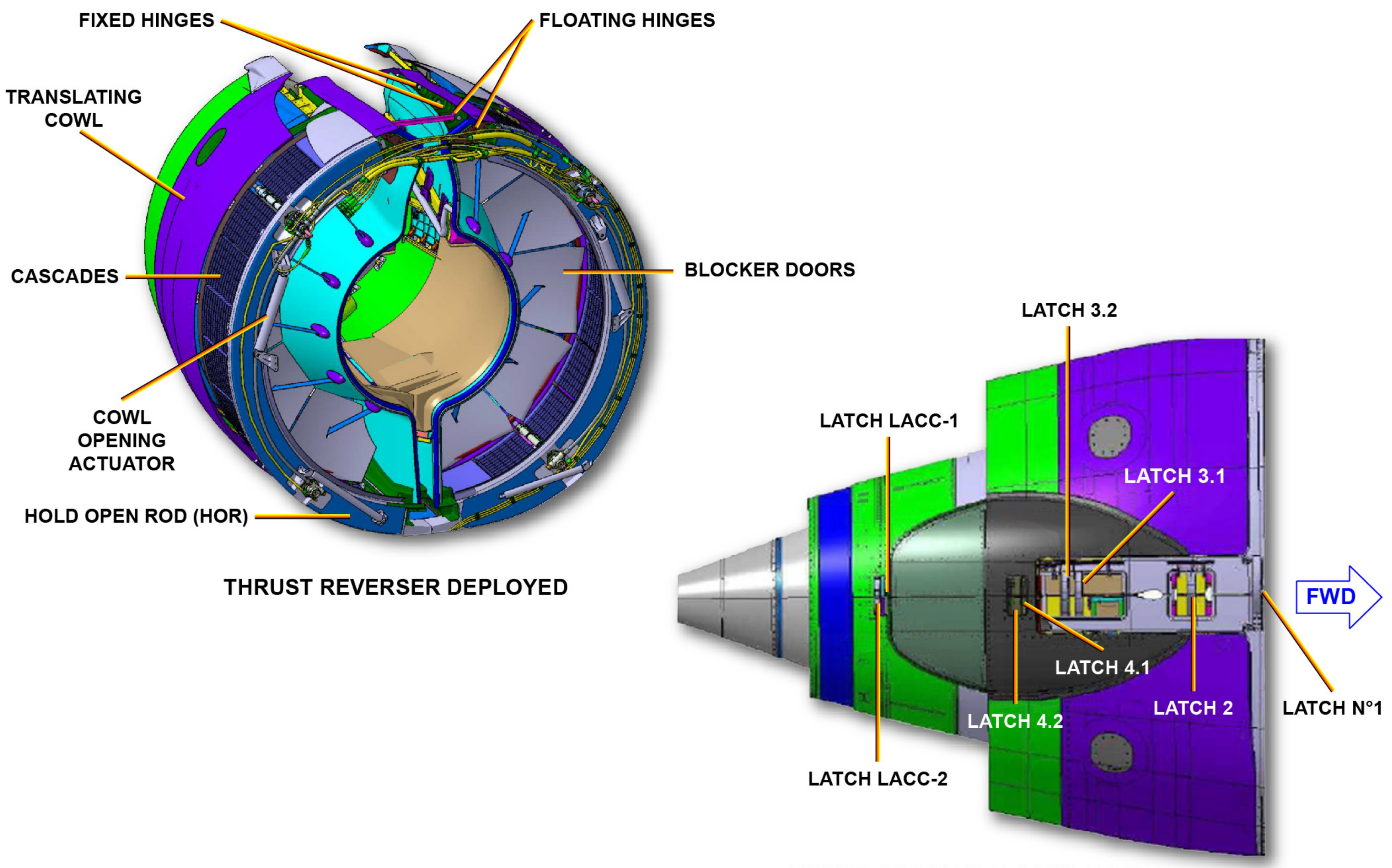
POWER PLANT INSTALLATION D/O

THRUST REVERSER COWL DOORS

The Thrust Reverser Cowl Doors (TRCD) or "C" Ducts are in 2 halves. Each half includes 1 translating sleeve, 2 actuators, 5 blockers doors and 10 cascades.
The TRCDs provide a smooth air flow around the engine area, enclose the engine core components and provide aerodynamic breaking when deployed.
Each Each half is supported by 4 hinges, 2 for the floating rods and 2 for the pylon attachment. The complete assembly is latched along the bottom centerline by 8 latches, named from front to rear: L1, L2, L3.1, L3.2, L4.1, L4.2, Latch Aft Core Cowl (LACC).1, and LACC.2.
For information:
- Latches opening sequence: L1 - L2 - L3.1 - L3.2 - L4.1 - L4.2 - LACC.1 - LACC.2,
- Latches closing sequence: LACC.2 - LACC.1 - L4.2 - L4.1 - L3.2 - L3.1 - L2 - L1.

Each half is provided with:
- 4 hoisting points for removal/installation,
- 1 hydraulic actuator operated externally by using a hand pump for opening/closing of the TRCD,
- 1 HOR.


FIXED HINGES
FLOATING HINGES
TRANSLATING COWL
CASCADES
BLOCKER DOORS
COWL OPENING ACTUATOR
HOLD OPEN ROD (HOR)
LATCH 3.2
LATCH LACC-1
LATCH 3.1
FWD
LATCH 4.1
LATCH 2
LATCH N°1
LATCH 4.2
LATCH LACC-2

THRUST REVERSER DEPLOYED

THRUST REVERSER COWL DOOR (TRCD) (BOTTOM VIEW)

LACC: Latch Aft Core Cowl

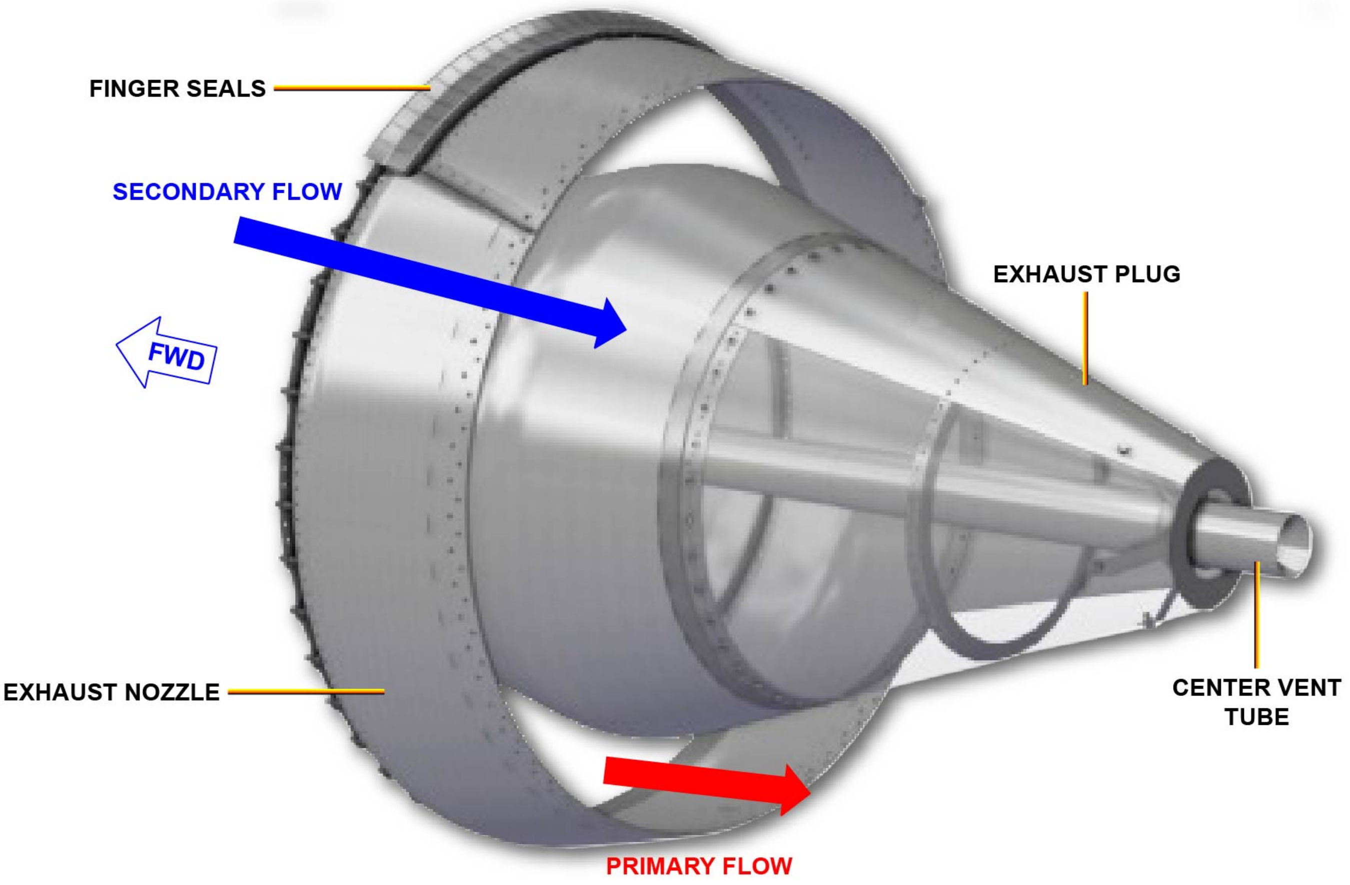
THRUST REVERSER COWL DOORS

POWER PLANT INSTALLATION D/O

EXHAUST

The hot exhaust is formed by the exhaust nozzle assembly and the exhaust plug assembly. Both are bolted on the engine exhaust case.
They provide the surfaces to guide the hot engine flow (Primary Flow) and the cold engine flow (Secondary Flow).
The finger seals at the top of the exhaust nozzle prevent any flame from entering the core compartment area in the event of fire.
2 drain holes are made at the lowest point of the exhaust nozzle outer and inner skins.
3 spigots are used to align the exhaust nozzle with the engine exhaust case.
The exhaust plug rear disk support the Center Vent Tube.
1 spigot is used to align the exhaust nozzle with the engine exhaust case.

EXHAUST

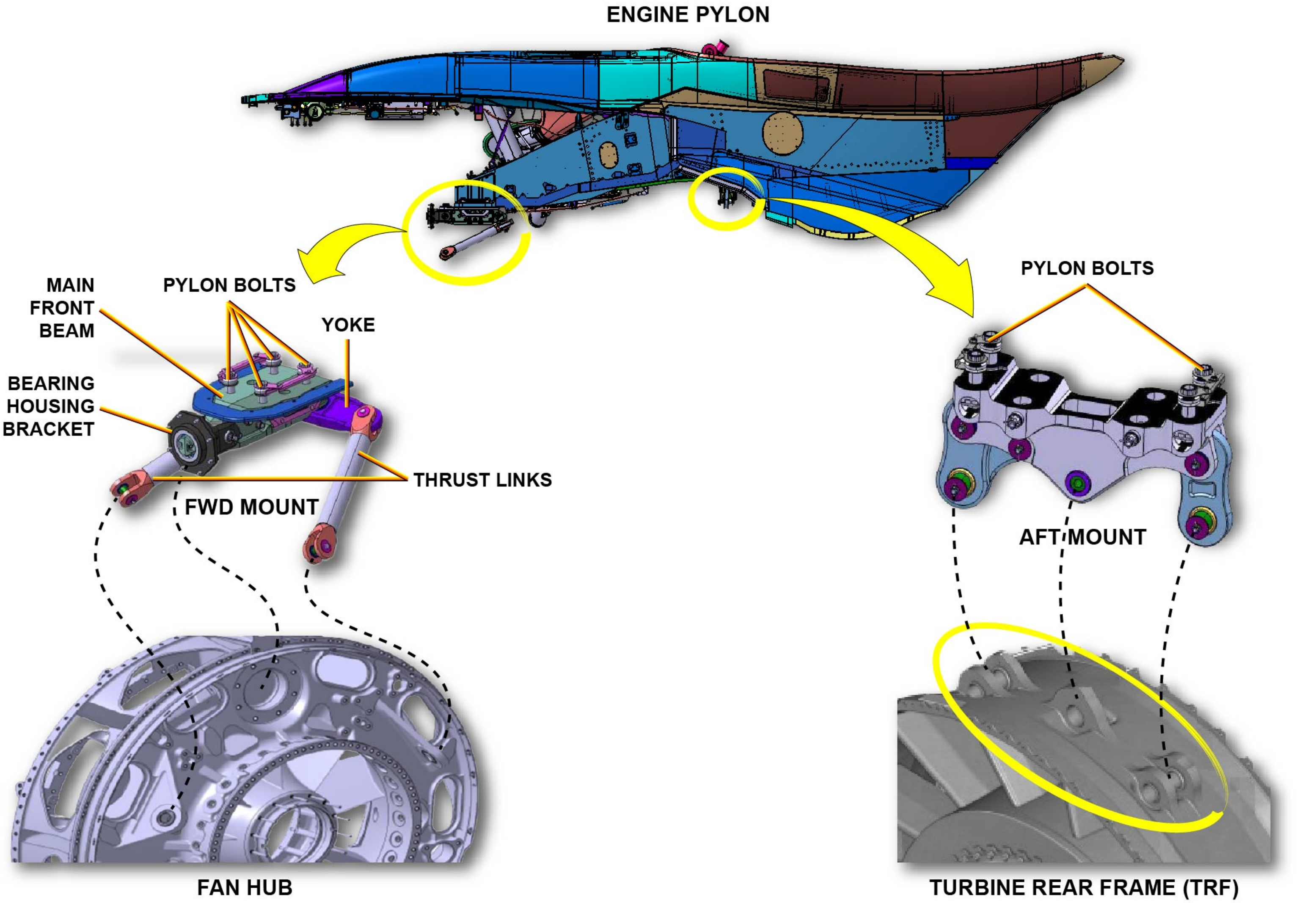

FINGER SEALS
SECONDARY FLOW
FWD
EXHAUST PLUG
EXHAUST NOZZLE
CENTER VENT TUBE
PRIMARY FLOW

EXHAUST

POWER PLANT INSTALLATION D/O

ENGINE MOUNTS

The engine is mounted to the pylon by the forward and rear mount assemblies. They sustain the engine and thrust loads.
The forward mount assembly comprises the bearing housing bracket, the main front beam, the balance beam (yoke) and two thrust links.
They transmit the entire thrust loads and part of the vertical and side loads.
The bearing housing bracket is bolted on the fan hub (Compressor Intermediate Case) at the 12 o'clock position and connected to the main front beam.
The thrust links are attached to each side of the fan hub and to the balance beam which is connected to the main front beam.
The main front beam is attached to the pylon with four high strength tension bolts and shear pins.
The rear mount transmits the entire engine/nacelle torque and part of the vertical and side loads.
The main bracket is connected to the pylon by four high strength tension bolts and shear pins and connected to the engine Turbine Rear Frame (TRF) at the 12 o'clock position with three bolts via two links and a fail-safe point.

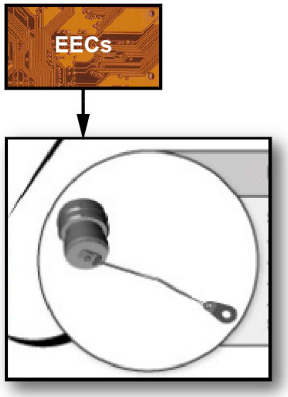

ENGINE PYLON
MAIN FRONT BEAM
PYLON BOLTS
YOKE
BEARING HOUSING BRACKET
THRUST LINKS
FWD MOUNT
PYLON BOLTS
AFT MOUNT
FAN HUB
TURBINE REAR FRAME (TRF)

ENGINE MOUNTS

ENGINE SYSTEM D/O

ENGINE CHARACTERISTICS

The Airbus A319, A320 and A321 NEO Aircraft are powered by two CFM LEAP - 1A turbofan engines.
This engine is a high by-pass ratio (11:1) dual spool turbofan engine.
This engine can produce a thrust from 23000 lbs (10400 kg) to 33000 lbs (14900 kg) depending on the aircraft version set by the Data Entry Plug (DEP) which is connected to the Electronic Engine Control (EEC).



DATA PLUG ENTRY

A/C	A/C model	Rating	Max Take-Off Thrust
A321	A321-251N (Basic)	LEAP-1A32	32.1 klbs
	A321-251N	LEAP-1A32B2	32.1 klbs + Bump
	A321-253N	LEAP-1A33	32.9 klbs
	A321-253N	LEAP-1A33B2	32.9 klbs + Bump
	A321-252N	LEAP-1A30	30.3 klbs
A320	A320-251N	LEAP-1A26E1	26.6 klbs Extended
	A320-251N (Basic)	LEAP-1A26	26.6 klbs
	A320-252N	LEAP-1A24	24.4 klbs
	A320-253N	LEAP-1A29	29 klbs
A319	A319-151N	LEAP-1A24E1	24.4 klbs Extended
	A319-151N (Basic)	LEAP-1A24	24.4 klbs
	A319-152N	LEAP-1A23	22.9 klbs
	A319-153N	LEAP-1A26E1	26.6 klbs Extended
	A319-153N	LEAP-1A26	26.6 klbs

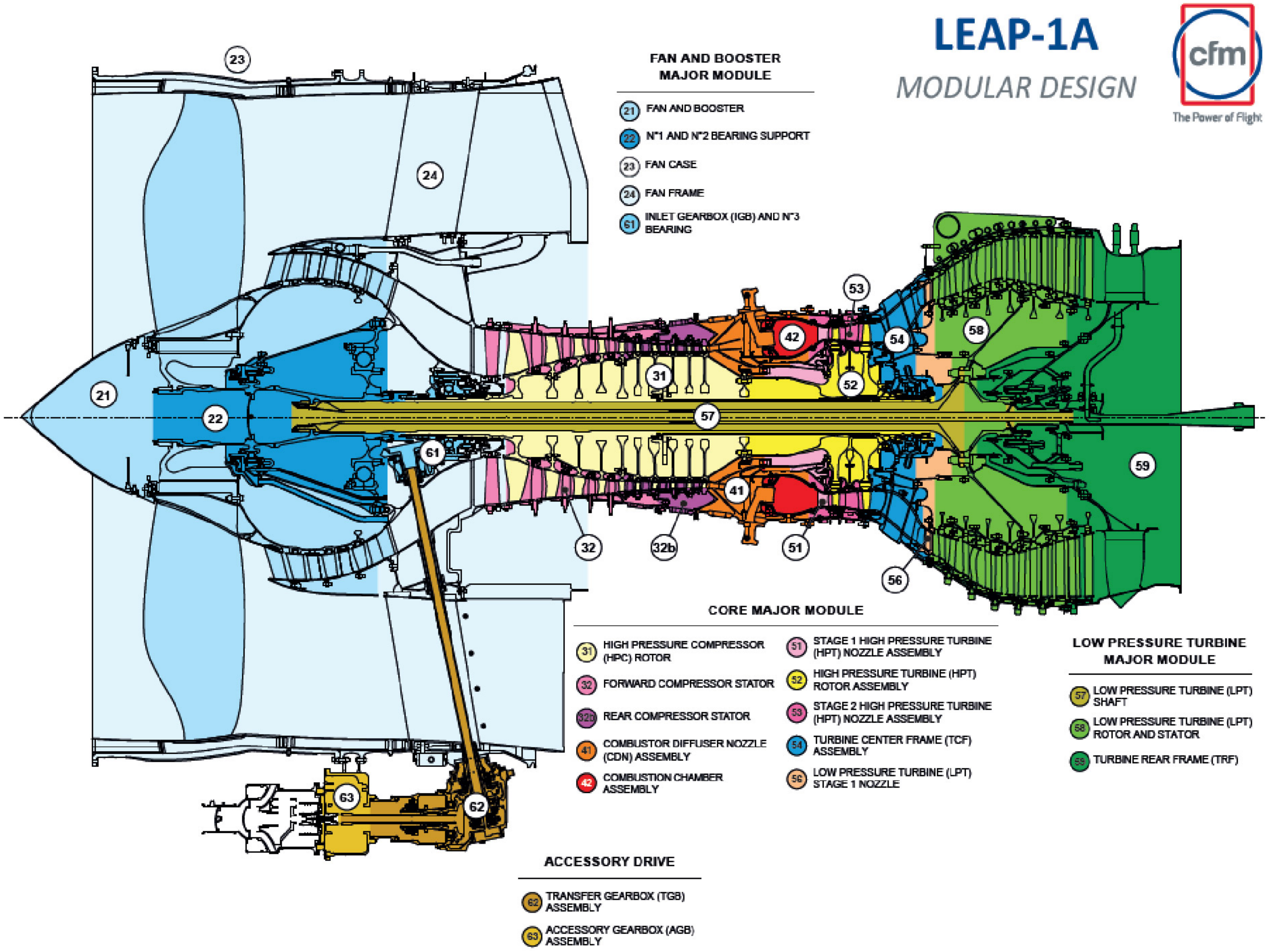
ENGINE CHARACTERISTICS

ENGINE SYSTEM D/O

ENGINE ARCHITECTURE

The Leap engine is a modular concept design engine. It has 20 different modules that are enclosed within three major modules and an accessory drive module.
The 3 Major modules are:
- Fan and Booster Module,
- Core Engine Major Module,
- Low Pressure Turbine (LPT) Major Module.

The major modules are divided in minor modules and such modular concept permits to replace a damaged minor or major module.

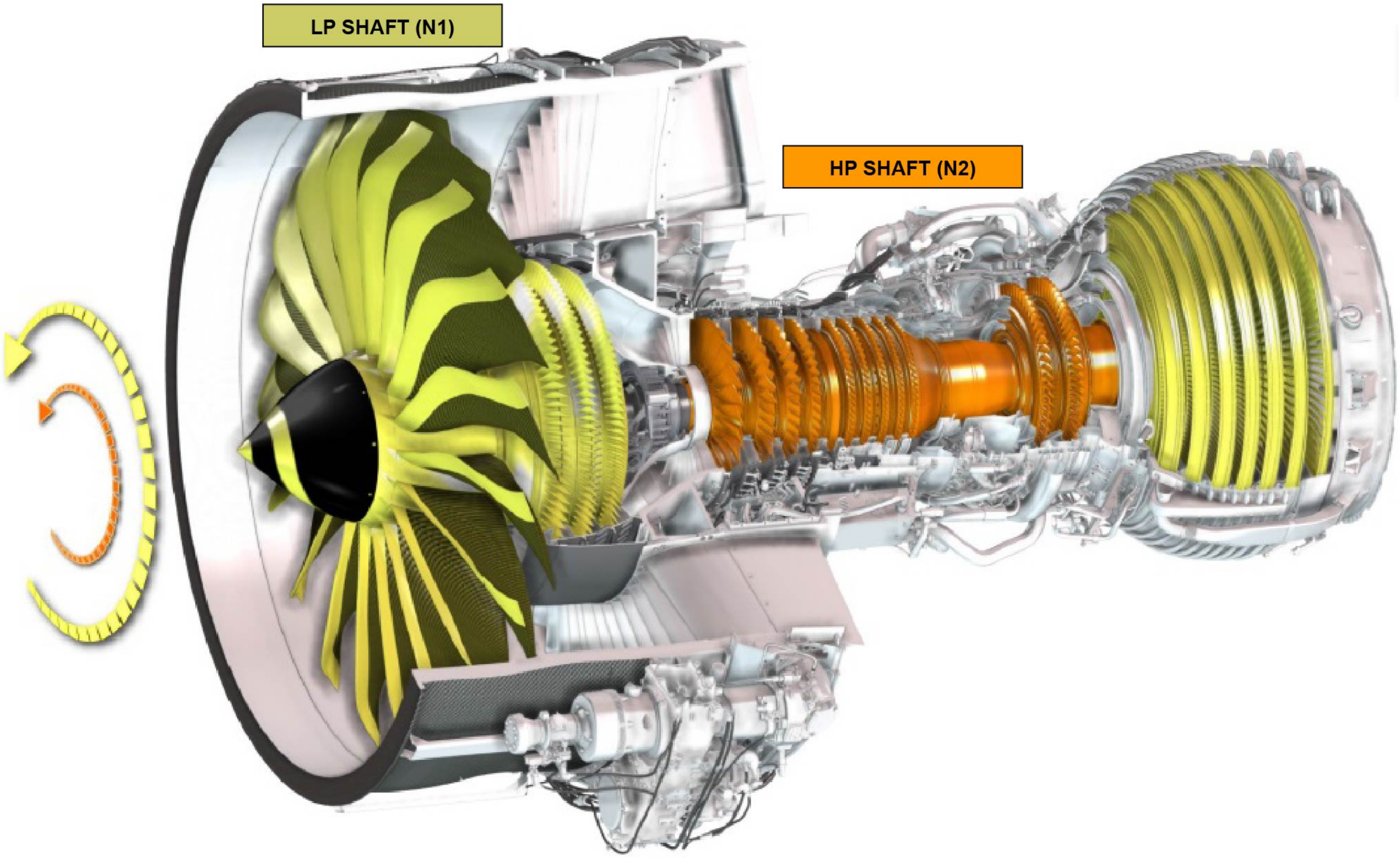

LEAP-1A
MODULAR DESIGN
cfm
The Power of Flight
FAN AND BOOSTER MAJOR MODULE
21 FAN AND BOOSTER
22 N°1 AND N°2 BEARING SUPPORT
23 FAN CASE
24 FAN FRAME
61 INLET GEARBOX (IGB) AND N°3 BEARING
CORE MAJOR MODULE
31 HIGH PRESSURE COMPRESSOR (HPC) ROTOR
32 FORWARD COMPRESSOR STATOR
32b REAR COMPRESSOR STATOR
41 COMBUSTOR DIFFUSER NOZZLE (CDN) ASSEMBLY
42 COMBUSTION CHAMBER ASSEMBLY
51 STAGE 1 HIGH PRESSURE TURBINE (HPT) NOZZLE ASSEMBLY
52 HIGH PRESSURE TURBINE (HPT) ROTOR ASSEMBLY
53 STAGE 2 HIGH PRESSURE TURBINE (HPT) NOZZLE ASSEMBLY
54 TURBINE CENTER FRAME (TCF) ASSEMBLY
56 LOW PRESSURE TURBINE (LPT) STAGE 1 NOZZLE
LOW PRESSURE TURBINE MAJOR MODULE
57 LOW PRESSURE TURBINE (LPT) SHAFT
58 LOW PRESSURE TURBINE (LPT) ROTOR AND STATOR
59 TURBINE REAR FRAME (TRF)
ACCESSORY DRIVE
62 TRANSFER GEARBOX (TGB) ASSEMBLY
63 ACCESSORY GEARBOX (AGB) ASSEMBLY
21
22
23
24
31
32
32b
41
42
51
52
53
54
56
57
58
59
61
62
63

ENGINE ARCHITECTURE

ENGINE SYSTEM D/O

ENGINE DESCRIPTION

The engine rotor comprises of a single stage fan, a 3 stage LP Compressor driven by a 7 stage LP Turbine and a 10 stage HP Compressor driven by a 2 stage HP Turbine.
The accessory drive section is located at the front of the engine, on the fan frame shroud at 8 o'clock.

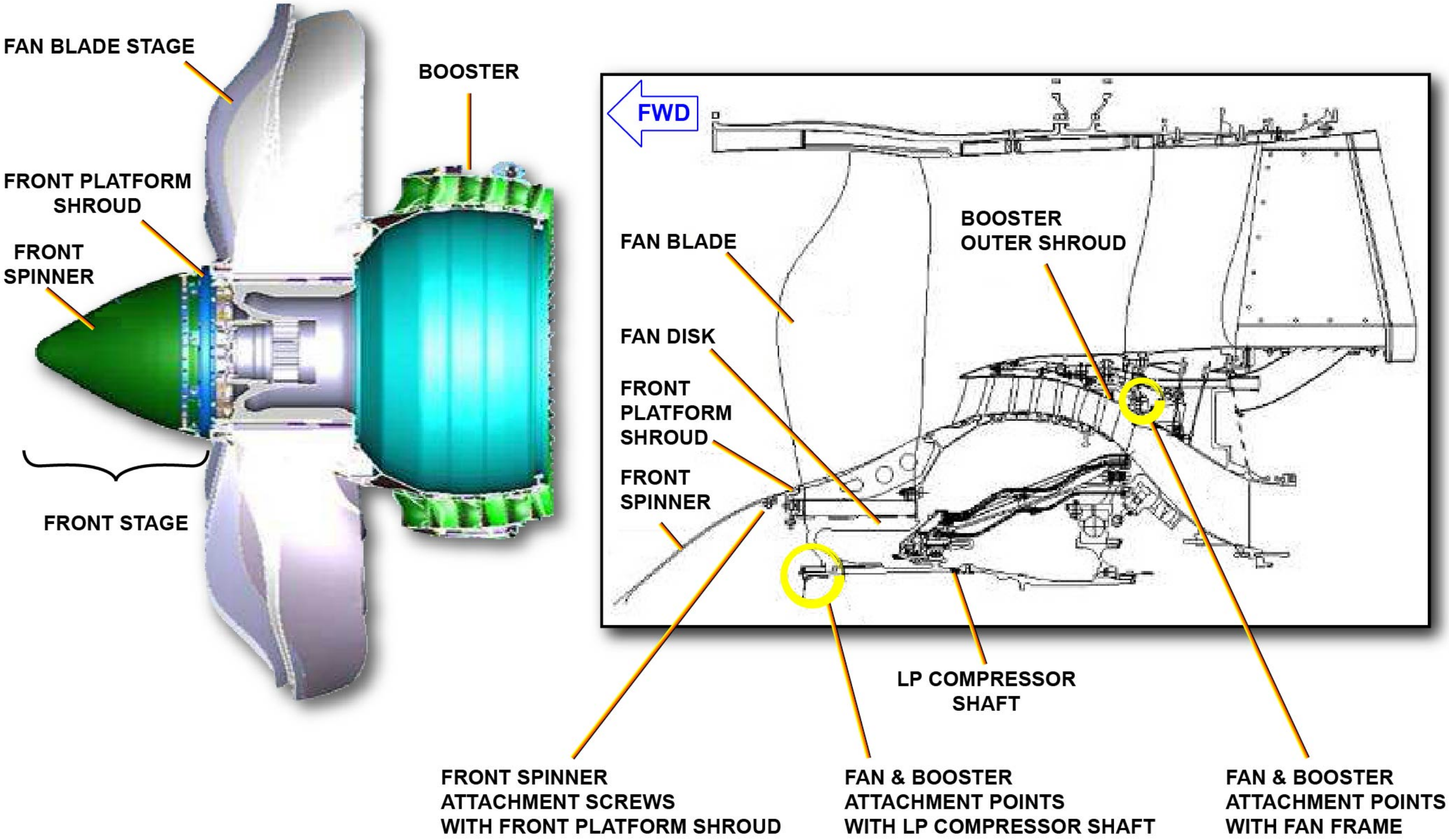

LP SHAFT (N1)
HP SHAFT (N2)

ENGINE DESCRIPTION

ENGINE SYSTEM D/O

FAN AND BOOSTER

The Fan and Booster module consists of a front stage, a fan stage and a 3-stage axial booster, mounted at the rear of the fan disk.
The Fan & Booster module located behind the Air Intakes Section is contained by the Fan Case Module and Fan Frame Module. Through the Fan disk, it is attached to and supported by the Compressor Shaft, attached to the LP shaft and driven by the LPT.
Through the Booster outer shroud it is attached to and supported by the Fan Frame Module.


FAN BLADE STAGE
BOOSTER
FRONT PLATFORM SHROUD
FRONT SPINNER
FRONT STAGE
FWD
FAN BLADE
BOOSTER OUTER SHROUD
FAN DISK
FRONT PLATFORM SHROUD
FRONT SPINNER
LP COMPRESSOR SHAFT
FRONT SPINNER ATTACHMENT SCREWS WITH FRONT PLATFORM SHROUD
FAN & BOOSTER ATTACHMENT POINTS WITH LP COMPRESSOR SHAFT
FAN & BOOSTER ATTACHMENT POINTS WITH FAN FRAME

FAN AND BOOSTER

ENGINE SYSTEM D/O

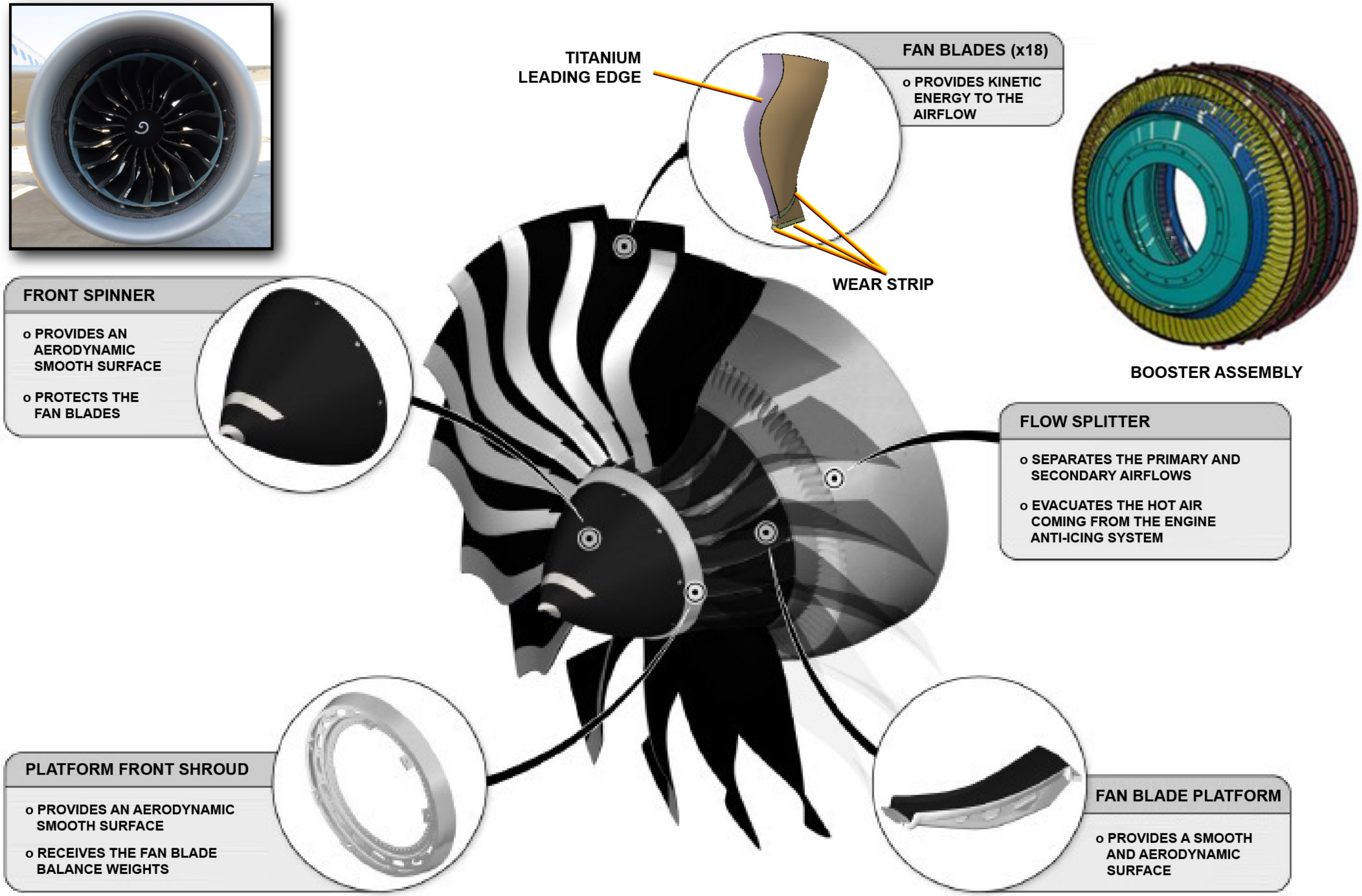
FAN AND BOOSTER (continued)

FAN STAGE

The Fan Stage consists of the Fan Disk, 18 Fan Blades and Fan Blade Platforms, Fan Blade Spacers, Fan Blade Locks and Fan Disk Shields.
The fan disk is titanium alloy forging and has 18 dovetail slots for installation of fan blades. The compressor shaft supports the Fan Disk which drives the Fan Blades. The wide chord Fan Blades are made of 3D woven composite material with leading edge in Titanium.
The composite Fan Blade Platforms are mounted between the Fan Blades to form the flow path of the Fan Hub and to make the airflow smooth.

BOOSTER

The Booster is a three-stage axial flow compressor, consisting of three-stage rotor spool and blades and four-stage stator vanes.
The axial-flow air compressor compresses air by accelerating the air and then diffusing the air to obtain a pressure increase. The air is accelerated by the three rows of rotating blades, and then diffused by a row of vanes which converts the velocity increase to a pressure rise.



FAN BLADES (x18)

- o PROVIDES KINETIC ENERGY TO THE AIRFLOW

FRONT SPINNER

- o PROVIDES AN AERODYNAMIC SMOOTH SURFACE
- o PROTECTS THE FAN BLADES

FLOW SPLITTER

- o SEPARATES THE PRIMARY AND SECONDARY AIRFLOWS
- o EVACUATES THE HOT AIR COMING FROM THE ENGINE ANTI-ICING SYSTEM

PLATFORM FRONT SHROUD

- o PROVIDES AN AERODYNAMIC SMOOTH SURFACE
- o RECEIVES THE FAN BLADE BALANCE WEIGHTS

FAN BLADE PLATFORM

- o PROVIDES A SMOOTH AND AERODYNAMIC SURFACE

FAN AND BOOSTER - FAN STAGE & BOOSTER

ENGINE SYSTEM D/O

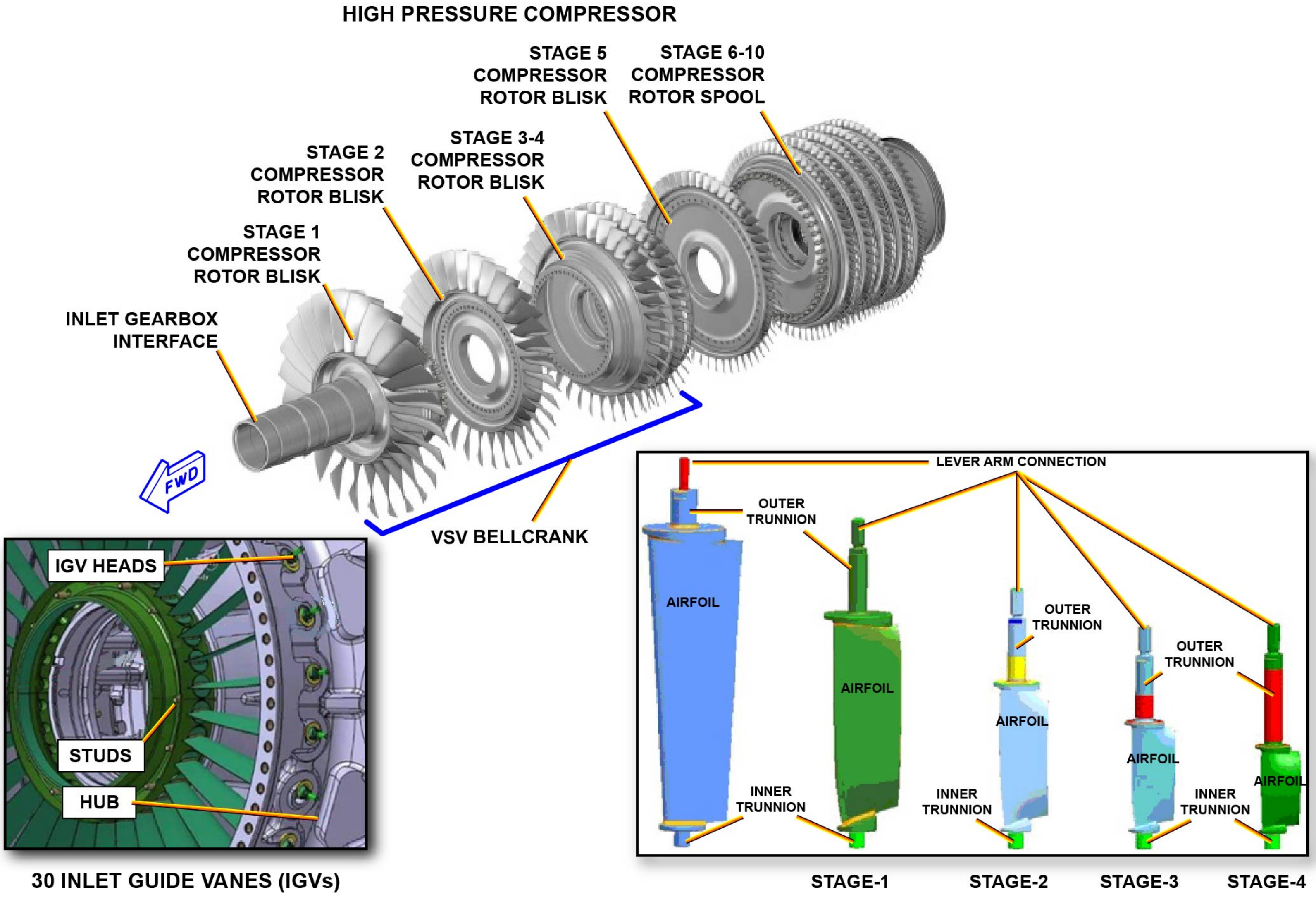
HIGH PRESSURE COMPRESSOR

The HPC is a ten-stage axial flow compressor consisting of:
- Inlet Guide Vane (IGV) Compressor Stator Vanes,
- 10 stage HPC Rotor, stages one through five are 3D-aero blade disks (Blisks) and stage 6-10 compressor rotor spool is five rotor disks manufactured as one component,
- 4 stage Front (Variable) Stators and Front Stator Case,
- 5 stage HPC Rear (Fixed) Stators and Aft Compressor Stator Extension Case.

The 30 IGVs, at the inlet of the HPC, are used to convert air velocity increase into a pressure rise and to direct air from the Booster to the Stage 1 HPC Rotor Blades for the optimum incidence angle and converts air velocity to air pressure.

The Variable Stator Vanes (VSVs) are used to direct the air to the next higher HPC stage. The IGVs and the VSVs are mechanically interconnected with linkage, external to the Forward Compressor Stator Case controlled by the EEC based on HPC rotor speed and HPC inlet temperature.

As the speed of the HPC Rotor increases, IGVs and VSVs will open; when the speed decreases, IGVs and VSVs will tend to close.

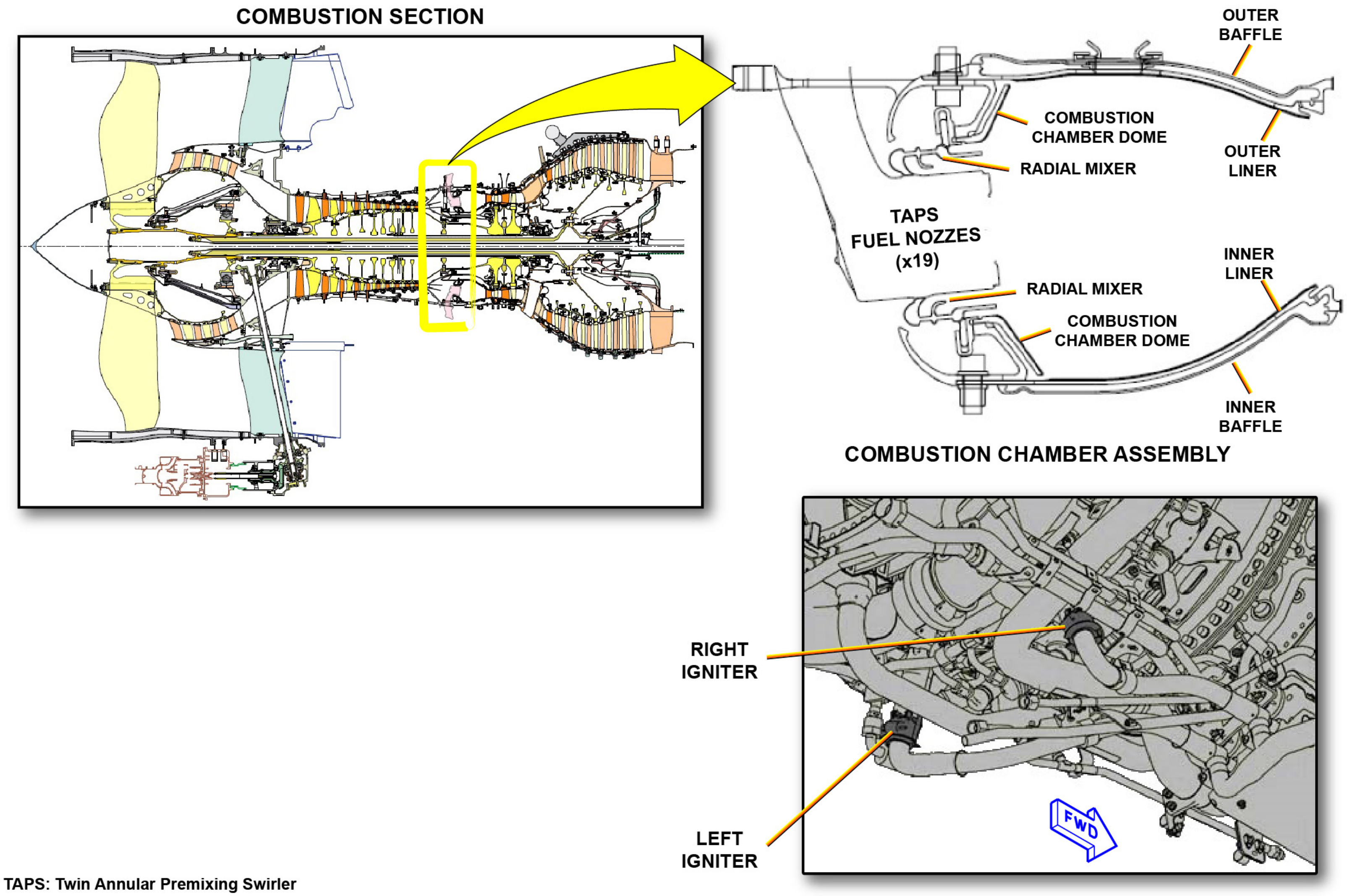

HIGH PRESSURE COMPRESSOR
STAGE 5 COMPRESSOR ROTOR BLISK
STAGE 6-10 COMPRESSOR ROTOR SPOOL
STAGE 3-4 COMPRESSOR ROTOR BLISK
STAGE 2 COMPRESSOR ROTOR BLISK
STAGE 1 COMPRESSOR ROTOR BLISK
INLET GEARBOX INTERFACE
FWD
VSV BELLCRANK
IGV HEADS
STUDS
HUB
30 INLET GUIDE VANES (IGVs)
LEVER ARM CONNECTION
OUTER TRUNNION
AIRFOIL
INNER TRUNNION
AIRFOIL
OUTER TRUNNION
AIRFOIL
INNER TRUNNION
OUTER TRUNNION
AIRFOIL
INNER TRUNNION
AIRFOIL
STAGE-1
STAGE-2
STAGE-3
STAGE-4

HIGH PRESSURE COMPRESSOR

ENGINE SYSTEM D/O

COMBUSTION SECTION

The Combustion Section consists of the Combustion Case Assembly and the Combustion Chamber Assembly.
The Combustion Section mixes fuel and HPC air for efficient and uniform combustion.
The Combustor Diffuser Nozzle Case supports the Combustion Chamber Assembly Inner and Outer Liners and provides a mounting location for 19 Fuel Nozzles and the 2 igniters.
The Twin Annular Premixing Swirler (TAPS) Fuel Nozzles introduce fuel to the Combustion Chamber and the Radial Mixers that mix the fuel and air required for combustion.


COMBUSTION SECTION
OUTER BAFFLE
COMBUSTION CHAMBER DOME
RADIAL MIXER
OUTER LINER
TAPS FUEL NOZZLES (x19)
INNER LINER
RADIAL MIXER
COMBUSTION CHAMBER DOME
INNER BAFFLE
COMBUSTION CHAMBER ASSEMBLY
RIGHT IGNITER
LEFT IGNITER
FWD

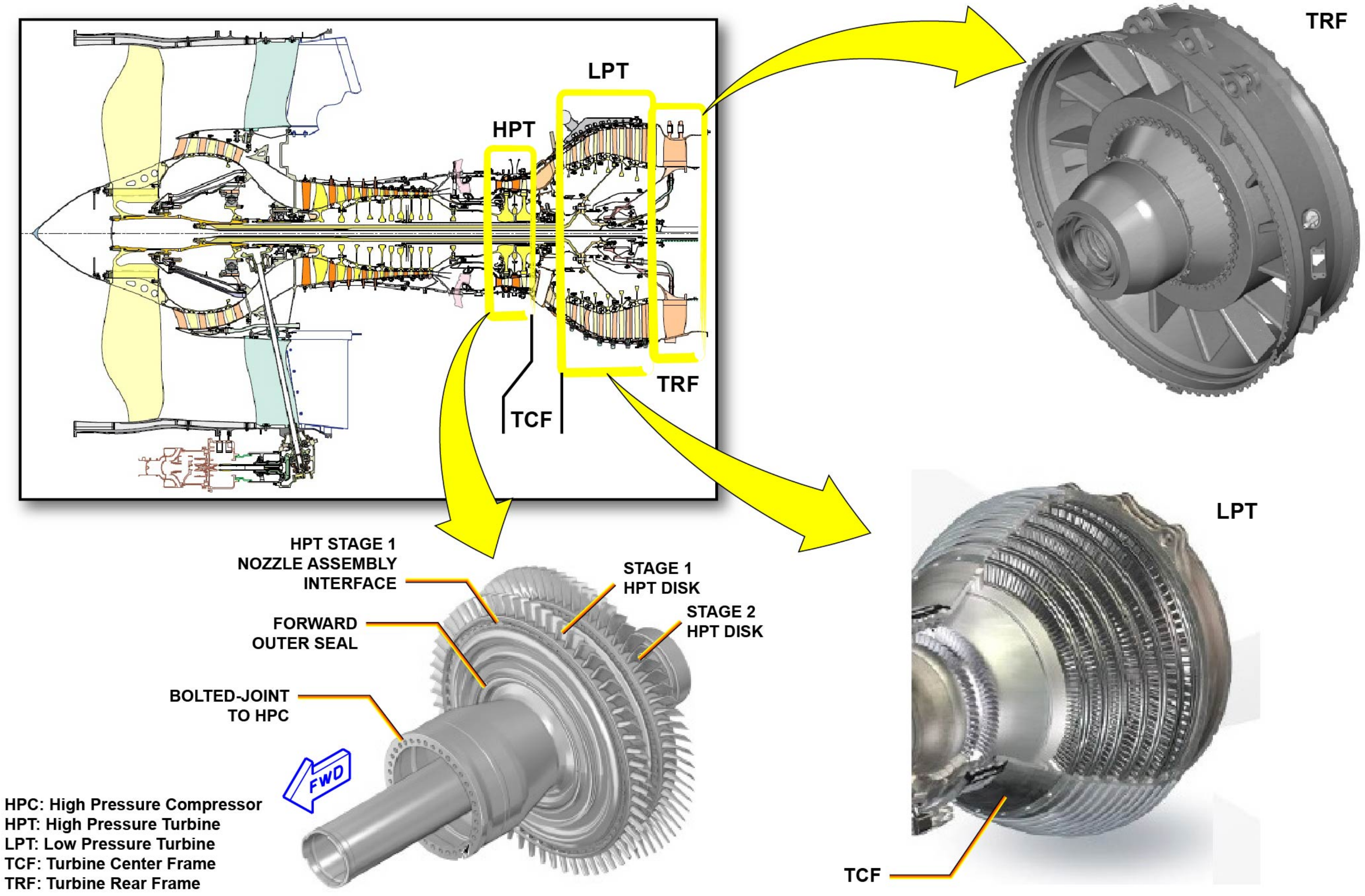
TAPS: Twin Annular Premixing Swirler

COMBUSTION SECTION

ENGINE SYSTEM D/O

TURBINES

The High-Pressure Turbine (HPT) is located between the combustion section and the Turbine Center Frame (TCF) assembly. The two stage HPT blades extract the energy from the hot gases from the combustion chamber, to drive the HPC and the Inlet Gearbox (IGB).
The HPT stage 1 nozzle assembly is connected to the combustion case assembly.
The HPT stage 2 nozzle assembly is connected to the front flange of the TCF by a bolted joint.
The Low-Pressure Turbine (LPT) is a 7 stage turbine. It is located between the TCF assembly and the Turbine Rear Frame (TRF) module. The LPT extracts the energy from the hot gases exiting the HPT, to drive the Fan and Booster rotor.
8 EGT sensors are installed around the TCF at the Inlet of the LPT.
The TRF bolted to the rear of the LPT case, directs a smooth aerodynamic primary airflow via the exhaust nozzle and plug. The outer casing is equipped with mounts for rear engine installation. Some of TRF struts allow the passage of oil tubes for the rear sump C.


LPT
HPT
TRF
TCF
TRF
LPT
HPT STAGE 1 NOZZLE ASSEMBLY INTERFACE
STAGE 1 HPT DISK
STAGE 2 HPT DISK
FORWARD OUTER SEAL
BOLTED-JOINT TO HPC
FWD
TCF

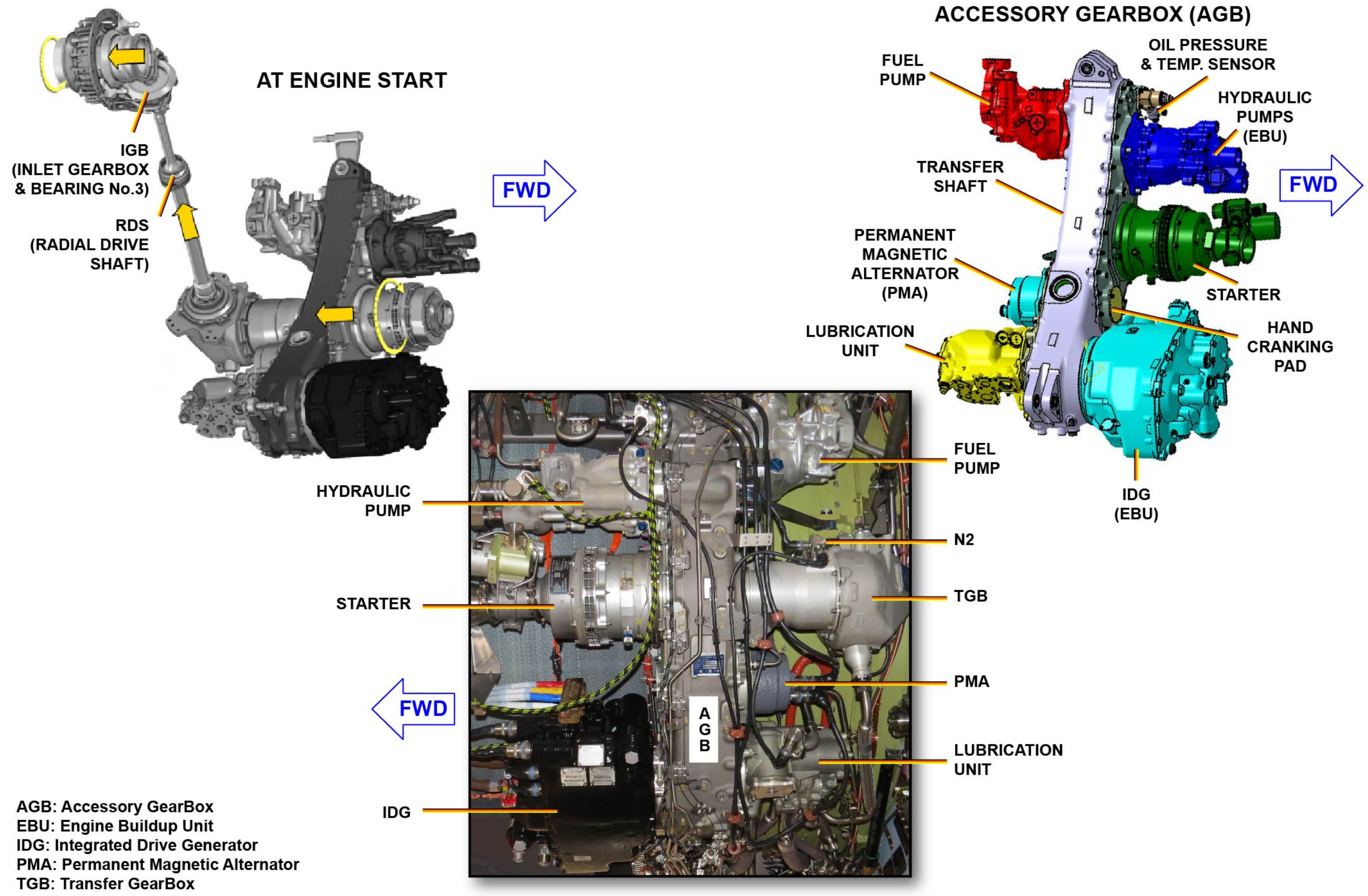
HPC: High Pressure Compressor
HPT: High Pressure Turbine
LPT: Low Pressure Turbine
TCF: Turbine Center Frame
TRF: Turbine Rear Frame

TURBINES

ENGINE SYSTEM D/O

ACCESSORY DRIVES SECTION

The Accessory Drives section consists of the Inlet Gearbox (IGB) module, the Transfer Gearbox (TGB) Module and the Accessory Gearbox (AGB) Module.
The IGB is located in the forward sump of the engine. TGB and AGB are located on the fan frame at 8 o'clock position.
During engine start, the pneumatic starter drives the spur gear assemblies of the AGB whose rotational energy is transmitted to the IGB via the transfer shaft of the TGB and the Radial Drive Shaft (RDS) to drive the core engine.
When the engine runs, the core engine drives the IGB which, in turn, drives the TGB and the AGB.
The crank pad to turn the HP rotor is located on the front of the AGB.
The N2 sensor is installed on the transfer tube between the TGB and the AGB.


AT ENGINE START
IGB (INLET GEARBOX & BEARING No.3)
RDS (RADIAL DRIVE SHAFT)
FWD
ACCESSORY GEARBOX (AGB)
FUEL PUMP
OIL PRESSURE & TEMP. SENSOR
HYDRAULIC PUMPS (EBU)
TRANSFER SHAFT
FWD
PERMANENT MAGNETIC ALTERNATOR (PMA)
STARTER
LUBRICATION UNIT
HAND CRANKING PAD
IDG (EBU)
HYDRAULIC PUMP
STARTER
FWD
IDG
AGB
FUEL PUMP
N2
TGB
PMA
LUBRICATION UNIT

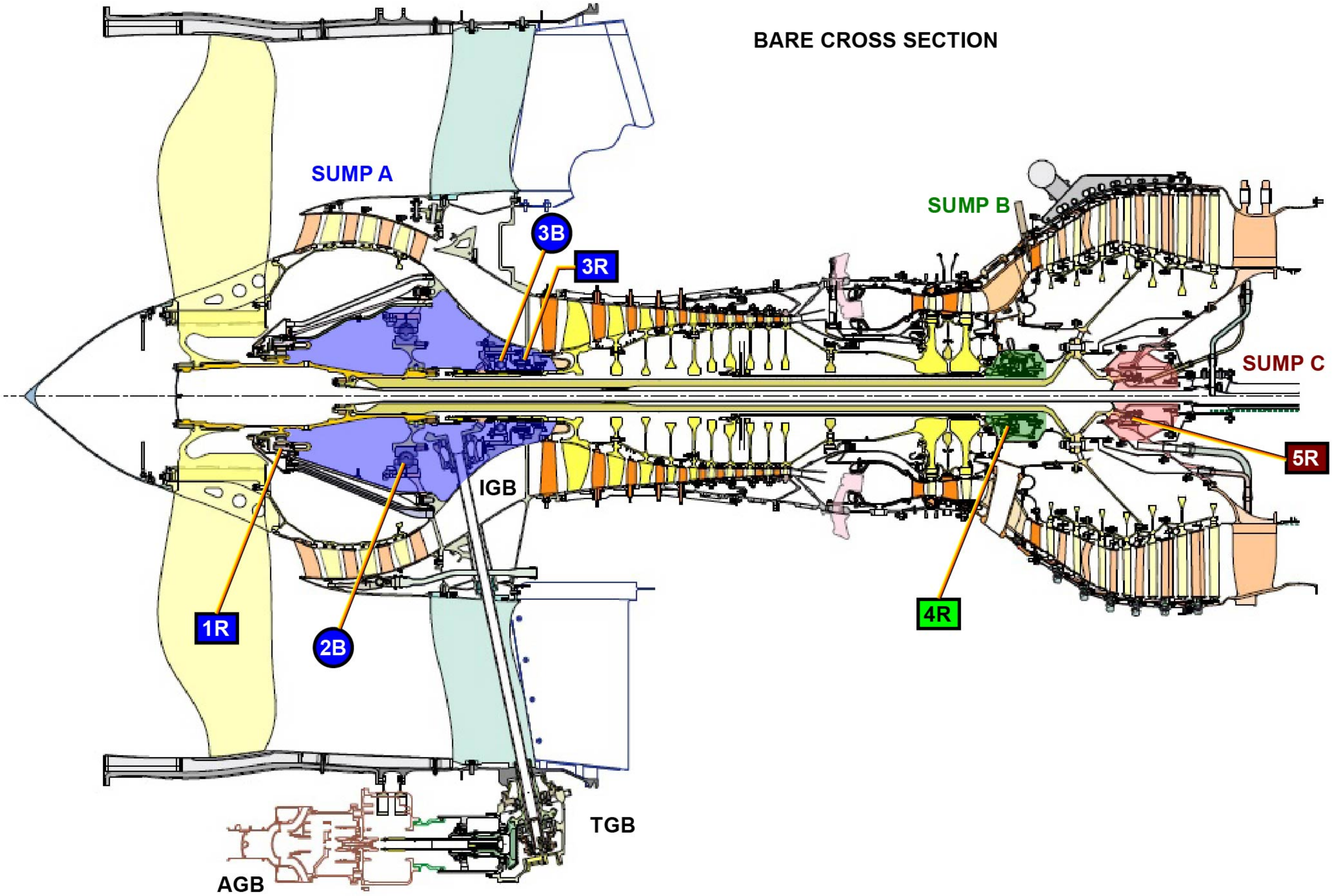
AGB: Accessory GearBox
EBU: Engine Buildup Unit
IDG: Integrated Drive Generator
PMA: Permanent Magnetic Alternator
TGB: Transfer GearBox

ACCESSORY DRIVES SECTION

ENGINE SYSTEM D/O

ENGINE BEARINGS

The engine bearings permit to handle engine rotors' axial and radial loads; their location in sumps allows permanent oil lubrication.
The Low Pressure rotor is supported by bearings 1R, 2B and 5R.
The High Pressure rotor is supported by bearings 3B, 3R and 4R.
At the Forward Sump A the N° 1 Roller Bearing provides radial support to the Fan and Booster Module.
At its rear, the N° 2 Ball Bearing provides radial and axial support to the Fan and Booster Module rotor.
The HPC Rotor is supported through the Front Shaft by the N° 3 Thrust Ball Bearing and N° 3 Cylindrical Roller Bearing located in the Forward Sump aft of the IGB.
The N° 4 Roller Bearing in the rear sump B handles radial loads from the rear end of HP rotor.
In the rear Sump C, N°5 bearing provides radial support to the LPT Rotor and the TRF module.
Two roller bearings and one ball bearing are installed on each TGB bevel gear assembly.
Two roller bearings are installed on each spur gear assembly located in the AGB.


BARE CROSS SECTION
SUMP A
SUMP B
SUMP C
3B
3R
IGB
5R
4R
1R
2B
TGB
AGB

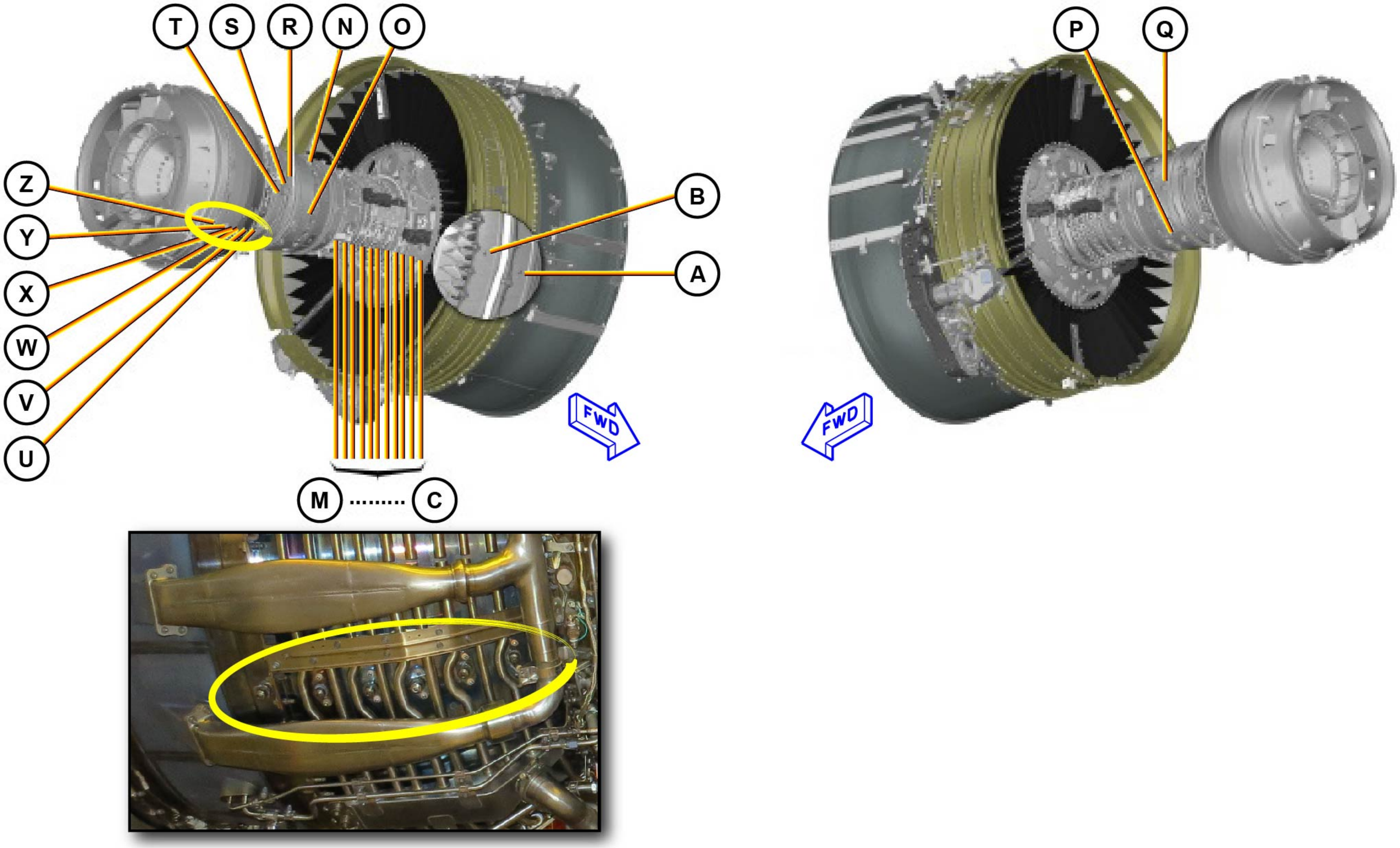
ENGINE BEARINGS

ENGINE SYSTEM D/O

BOROSCOPIC PORTS

Several boroscopic ports are provided for preliminary inspection of the gas path, internal parts condition checks without engine disassembly.
Most of them are located on the right hand side.
Each stage of the rotor, both compressors and turbines has boroscopic ports located at different positions on the engine case.
The combustion chamber has 4 ports (N to Q); O & P are the left and right Igniter ports.

ENGINE BOROSCOPIC PORTS

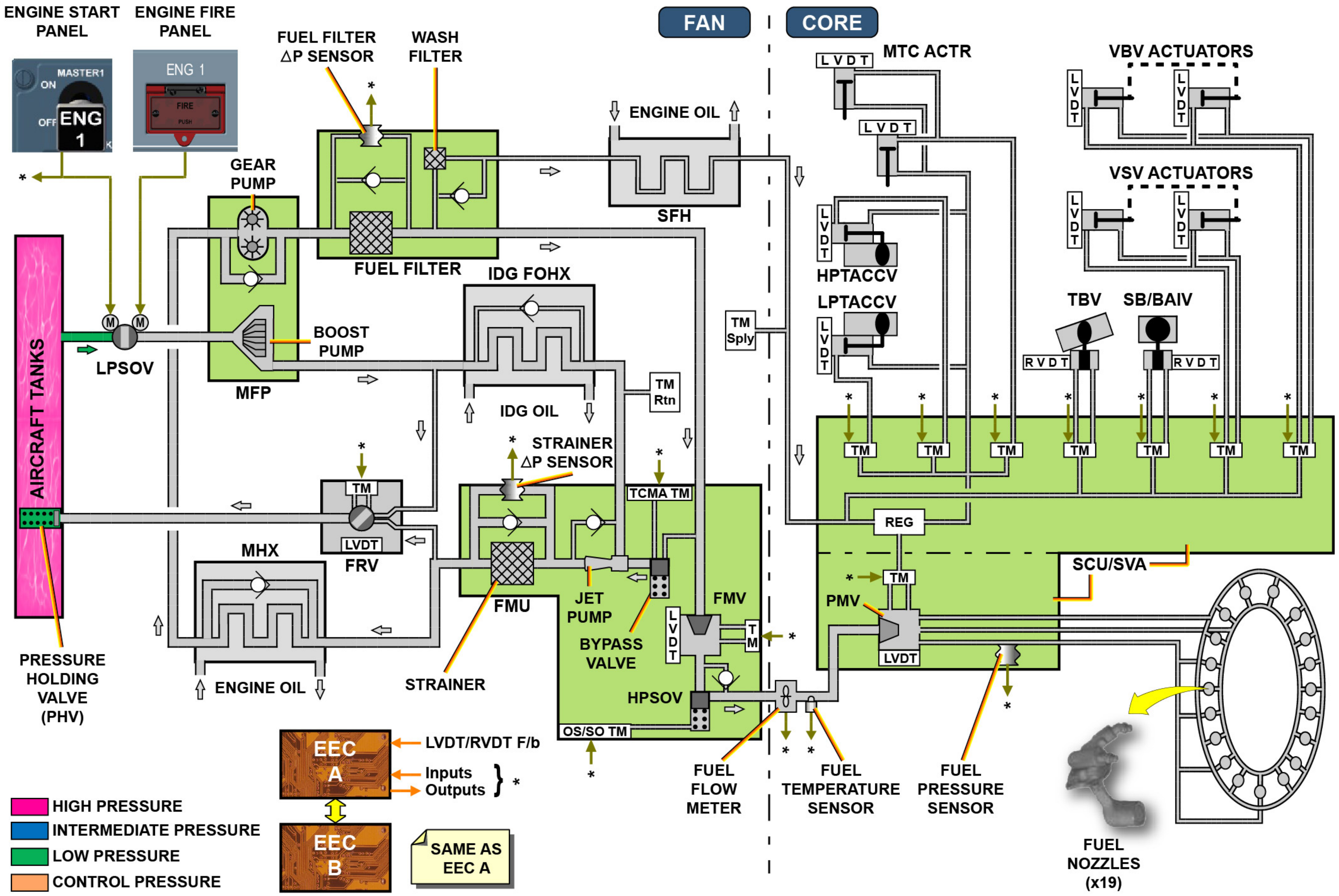

T
S
R
N
O
P
Q
Z
Y
X
W
V
U
B
A
M ……… C
FWD
FWD

BOROSCOPIC PORTS

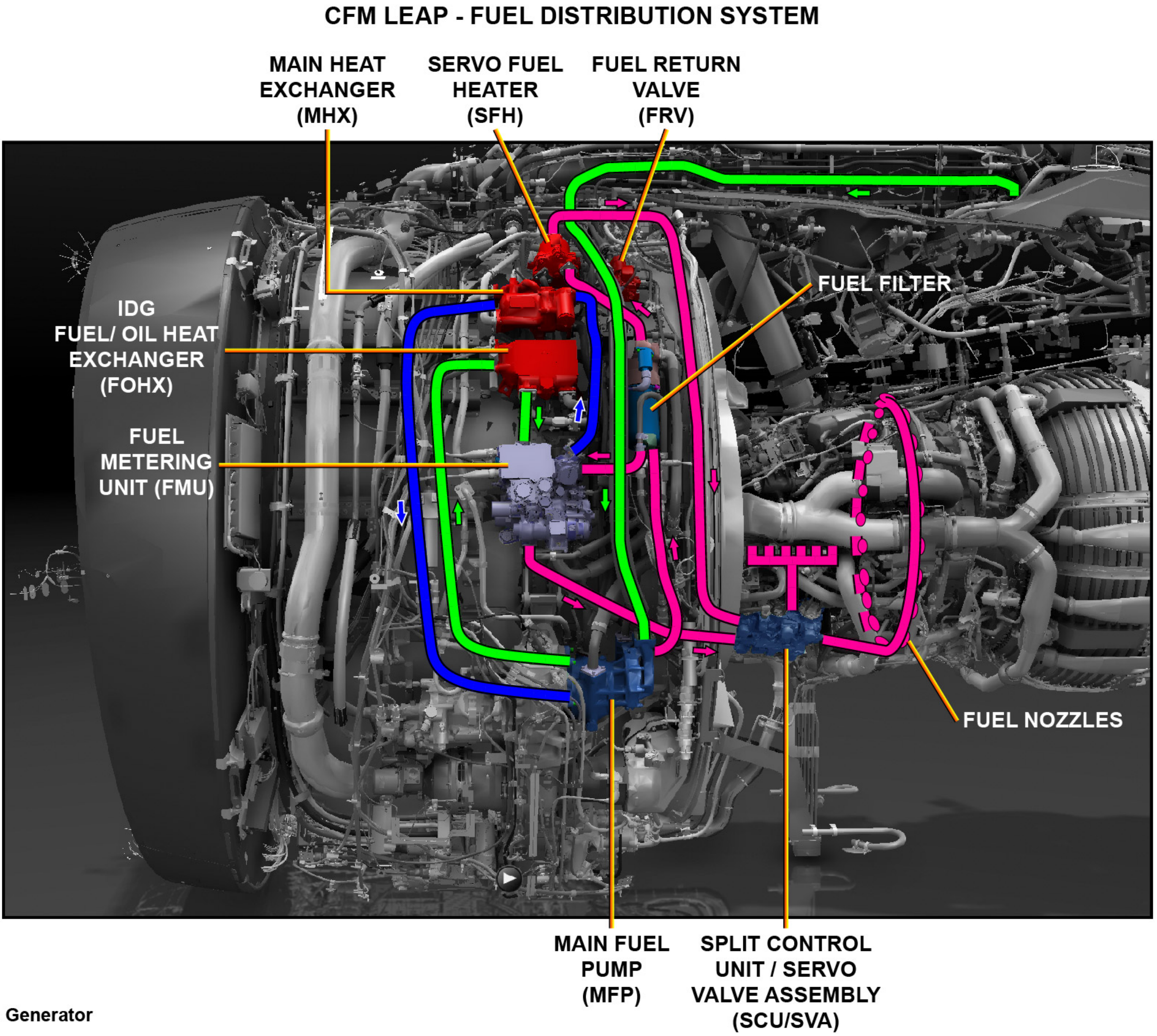
ENGINE FUEL SYSTEM D/O

FUEL SYSTEM LAYOUT

The fuel system supplies fuel from tanks to the engines. The fuel is pressurized, filtered, metered and supplied at the pressure and flow rate necessary to enable stable engine operations during all the phases. The metered Fuel Flow (FF) is sent to the fuel nozzles for combustion and the Servo Fuel is supplied to the fuel-operated components and actuators of the engine. The fuel is heated to prevent ice formation and used to cool engine oil and Integrated Drive Generator (IDG) oil.
The distribution system consists of:
- The Main Fuel Pump (MFP),
- Three Fuel/Oil Heat eXchangers (FOHX),
- The Fuel Metering Unit (FMU),
- The fuel filter,
- The Split Control Unit/Servo Valve Assembly (SCU/SVA),
- Nineteen Fuel nozzles,
- The Fuel Return Valve (FRV).


ENGINE START PANEL
MASTER1
ON
OFF
ENG 1
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
FUEL FILTER ΔP SENSOR
WASH FILTER
FAN
CORE
ENGINE OIL
SFH
MTC ACTR
LVDT
VBV ACTUATORS
VSV ACTUATORS
GEAR PUMP
FUEL FILTER
IDG FOHX
HPTACCV
LPTACCV
TBV
SB/BAIV
RVDT
AIRCRAFT TANKS
LPSOV
M
BOOST PUMP
MFP
IDG OIL
TM Sply
TM Rtn
TM
STRAINER ΔP SENSOR
TCMA TM
REG
LVDT
FRV
MHX
FMU
JET PUMP
BYPASS VALVE
FMV
SCU/SVA
PMV
HPSOV
OS/SO TM
PRESSURE HOLDING VALVE (PHV)
ENGINE OIL
STRAINER
EEC A
EEC B
LVDT/RVDT F/b
Inputs
Outputs
SAME AS EEC A
FUEL FLOW METER
FUEL TEMPERATURE SENSOR
FUEL PRESSURE SENSOR
FUEL NOZZLES (x19)
HIGH PRESSURE
INTERMEDIATE PRESSURE
LOW PRESSURE
CONTROL PRESSURE
*

FUEL SYSTEM LAYOUT


CFM LEAP - FUEL DISTRIBUTION SYSTEM
MAIN HEAT EXCHANGER (MHX)
SERVO FUEL HEATER (SFH)
FUEL RETURN VALVE (FRV)
IDG FUEL/ OIL HEAT EXCHANGER (FOHX)
FUEL METERING UNIT (FMU)
FUEL FILTER
FUEL NOZZLES
MAIN FUEL PUMP (MFP)
SPLIT CONTROL UNIT / SERVO VALVE ASSEMBLY (SCU/SVA)

IDG: Integrated Drive Generator

FUEL SYSTEM LAYOUT

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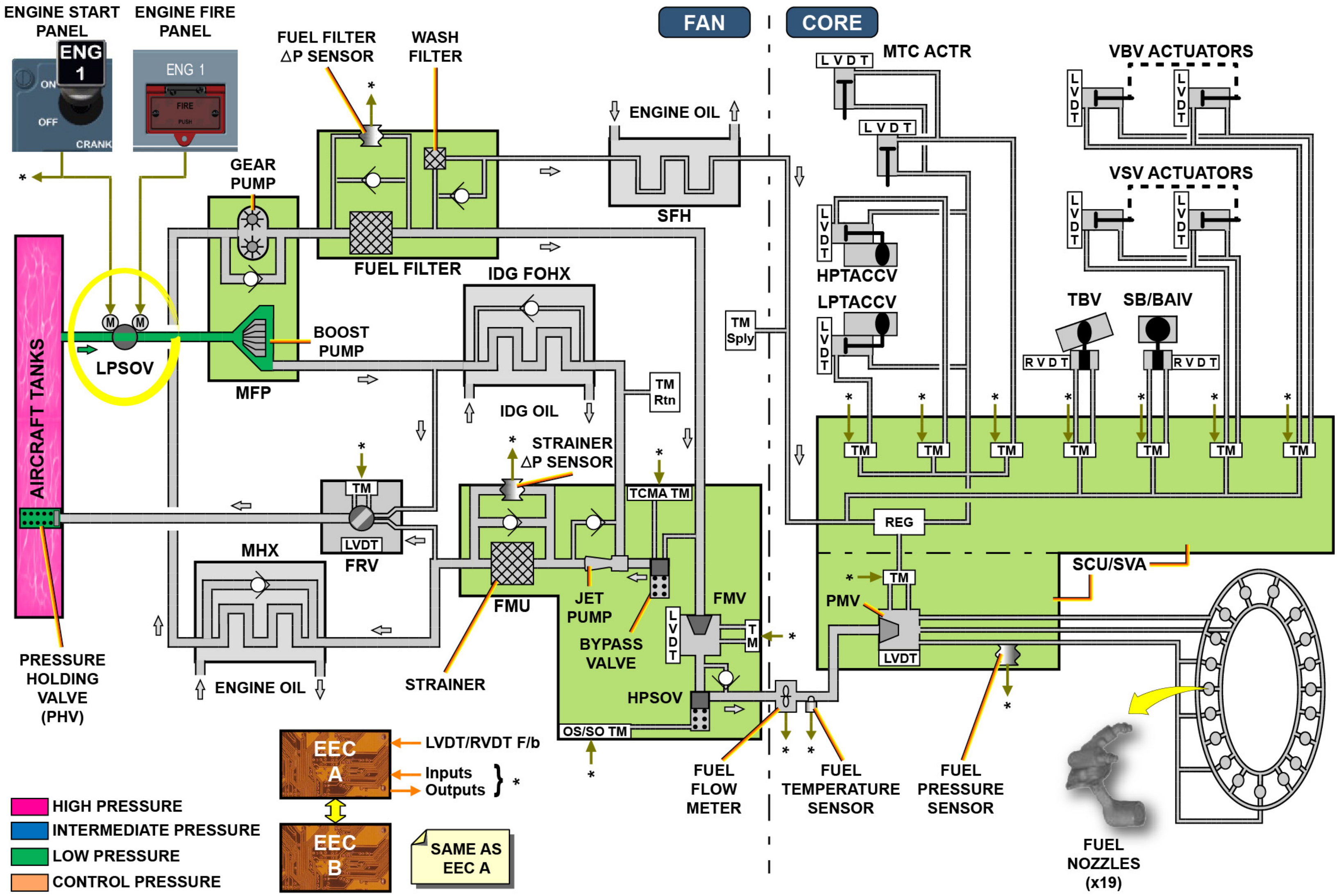
ENGINE FUEL SYSTEM D/O

FUEL FEED FROM AIRCRAFT

The Low Pressure Shut-Off Valve (LPSOV) is installed on the wing tank front spar, in the fuel supply line to the engine. Each LPSOV is controlled by a dual electrical motor. When the ENGine MASTER Lever is selected ON, the LPSOV opens and the fuel from the aircraft tanks flows to the inlet port of the Boost pump within the MFP.


ENGINE START PANEL
ENG 1
ON
OFF
CRANK
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
FUEL FILTER ΔP SENSOR
WASH FILTER
FAN
CORE
ENGINE OIL
SFH
MTC ACTR
LVDT
VBV ACTUATORS
VSV ACTUATORS
GEAR PUMP
FUEL FILTER
IDG FOHX
HPTACCV
LPTACCV
TBV
SB/BAIV
RVDT
AIRCRAFT TANKS
M
M
LPSOV
BOOST PUMP
MFP
TM Sply
TM Rtn
IDG OIL
TM
STRAINER ΔP SENSOR
TCMA TM
REG
SCU/SVA
LVDT
FRV
MHX
FMU
JET PUMP
BYPASS VALVE
FMV
PMV
HPSOV
OS/SO TM
PRESSURE HOLDING VALVE (PHV)
ENGINE OIL
STRAINER
EEC A
LVDT/RVDT F/b
Inputs
Outputs
EEC B
SAME AS EEC A
FUEL FLOW METER
FUEL TEMPERATURE SENSOR
FUEL PRESSURE SENSOR
FUEL NOZZLES (x19)
*
HIGH PRESSURE
INTERMEDIATE PRESSURE
LOW PRESSURE
CONTROL PRESSURE

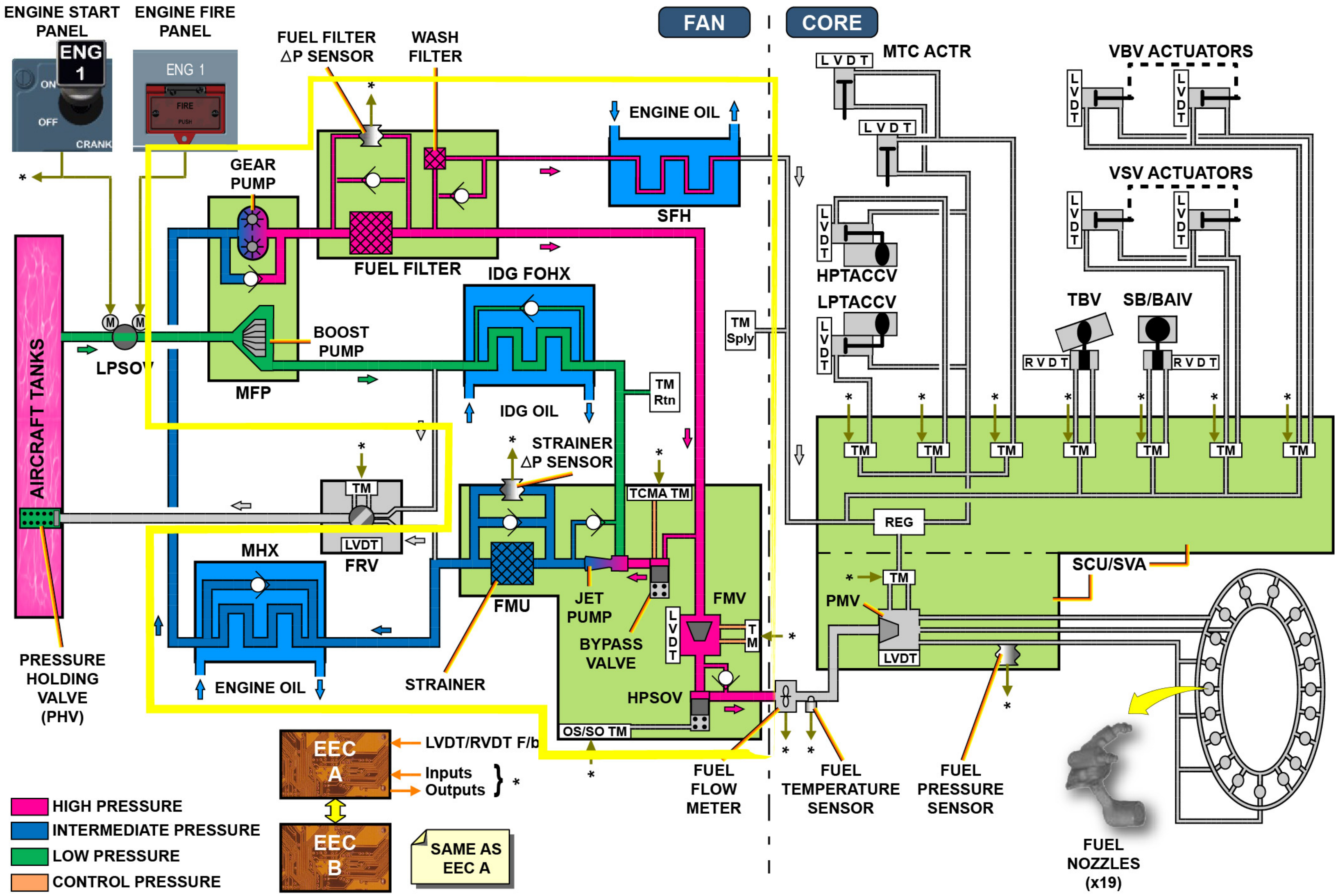
FUEL FEED FROM AIRCRAFT

ENGINE FUEL SYSTEM D/O

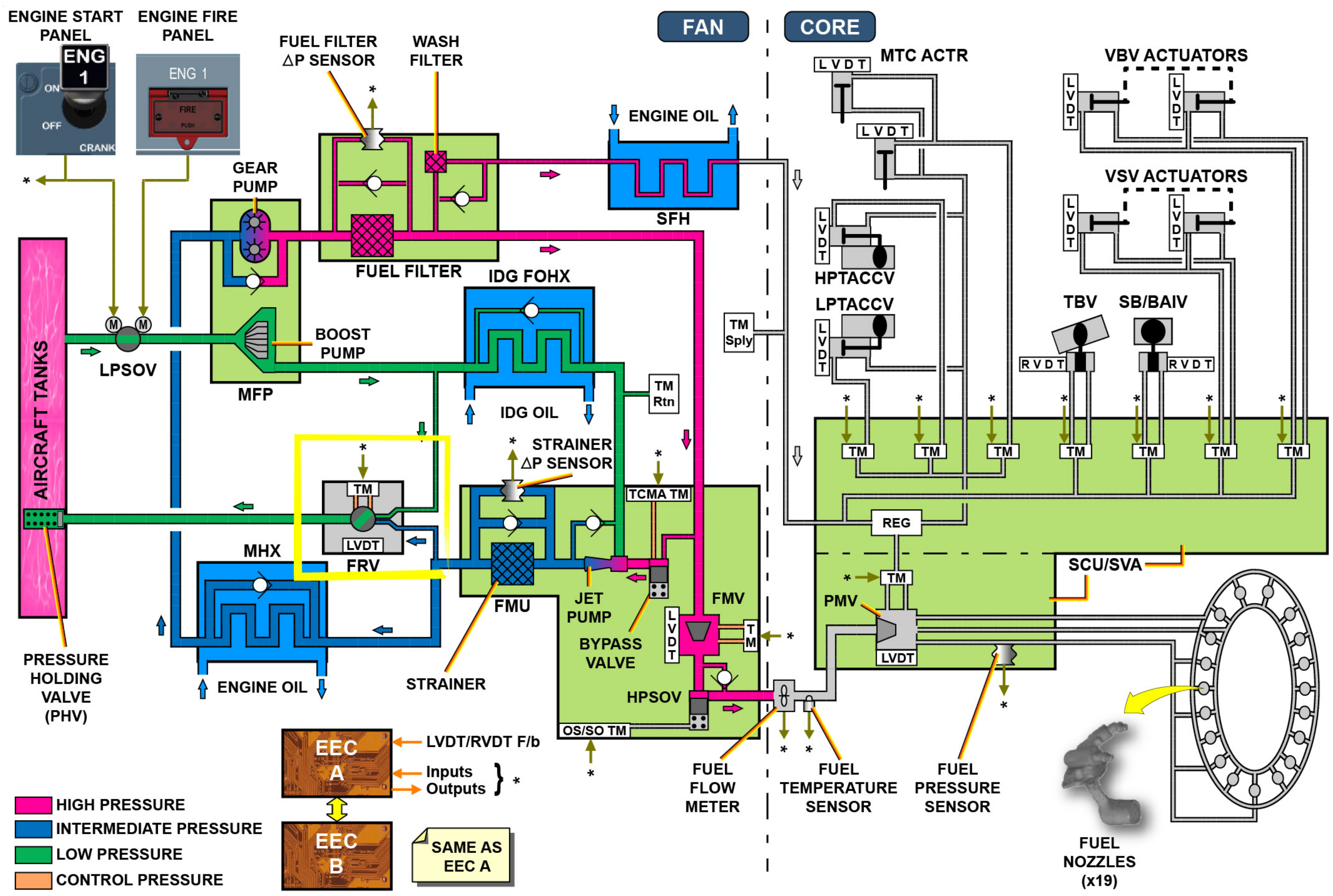
FAN AREA

The Boost Pump pushes LP fuel through the IDG FOHX to the FMU.
The fuel passes through the Jet Pump and the strainer before leaving the FMU and going to the Gear Pump via the Main Heat Exchanger (MHX).
The HP fuel is filtered and divided into two parts inside the Fuel Filter.
- The main part is the fuel for combustion. It is sent to the FMU where it is metered by the Fuel Metering Valve (FMV) and sent to the SCU/SVA via the High Pressure Shut-Off Valve (HPSOV). If a Thrust Control Malfunction (TCM) event occurs, the Bypass Valve will reduce the amount of fuel for combustion and mix it with the Intermediate Pressure fuel in the Jet Pump.
- The other part is the servo fuel. It is heated by the Servo Fuel Heater (SFH) before going to the SCU/SVA.

The Bypass Valve, FMV and HPSOV are controlled via their related Torque Motor (TM) by the Electronic Engine Control (EEC).
The FMV is monitored directly by a dual Linear Variable Differential Transducer (LVDT) and indirectly by the Fuel Flow Meter (FFM).
The HPSOV is monitored indirectly by the Fuel Pressure Sensor (FPS) versus the N2 speed.
For IDG oil temperature control, the FRV mixes cold LP fuel and hot IP fuel and modulates the return of the mixed fuel back to the aircraft fuel tanks when necessary.
The FRV is controlled via its Torque Motor (TM) by the EEC depending on the fuel temperature.


ENGINE START PANEL
ENG 1
ON
OFF
CRANK
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
FUEL FILTER ΔP SENSOR
WASH FILTER
FAN
CORE
MTC ACTR
LVDT
VBV ACTUATORS
ENGINE OIL
GEAR PUMP
SFH
FUEL FILTER
IDG FOHX
VSV ACTUATORS
HPTACCV
LPTACCV
TBV
SB/BAIV
RVDT
TM Sply
AIRCRAFT TANKS
LPSOV
BOOST PUMP
MFP
IDG OIL
TM Rtn
STRAINER ΔP SENSOR
TM
LVDT
FRV
TCMA TM
MHX
REG
SCU/SVA
FMU
JET PUMP
BYPASS VALVE
FMV
PMV
HPSOV
STRAINER
ENGINE OIL
OS/SO TM
PRESSURE HOLDING VALVE (PHV)
EEC A
EEC B
LVDT/RVDT F/b
Inputs
Outputs
SAME AS EEC A
FUEL FLOW METER
FUEL TEMPERATURE SENSOR
FUEL PRESSURE SENSOR
FUEL NOZZLES (x19)
HIGH PRESSURE
INTERMEDIATE PRESSURE
LOW PRESSURE
CONTROL PRESSURE
*

FAN AREA


ENGINE START PANEL
ENG 1
ON
OFF
CRANK
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
FUEL FILTER ΔP SENSOR
WASH FILTER
FAN
CORE
ENGINE OIL
SFH
MTC ACTR
LVDT
VBV ACTUATORS
VSV ACTUATORS
GEAR PUMP
FUEL FILTER
IDG FOHX
HPTACCV
LPTACCV
TBV
SB/BAIV
RVDT
AIRCRAFT TANKS
M
LPSOV
BOOST PUMP
MFP
TM Sply
TM Rtn
IDG OIL
STRAINER ΔP SENSOR
TCMA TM
TM
LVDT
FRV
MHX
REG
SCU/SVA
PMV
FMU
JET PUMP
BYPASS VALVE
FMV
HPSOV
OS/SO TM
PRESSURE HOLDING VALVE (PHV)
ENGINE OIL
STRAINER
EEC A
EEC B
LVDT/RVDT F/b
Inputs
Outputs
SAME AS EEC A
FUEL FLOW METER
FUEL TEMPERATURE SENSOR
FUEL PRESSURE SENSOR
FUEL NOZZLES (x19)
*
HIGH PRESSURE
INTERMEDIATE PRESSURE
LOW PRESSURE
CONTROL PRESSURE

FAN AREA

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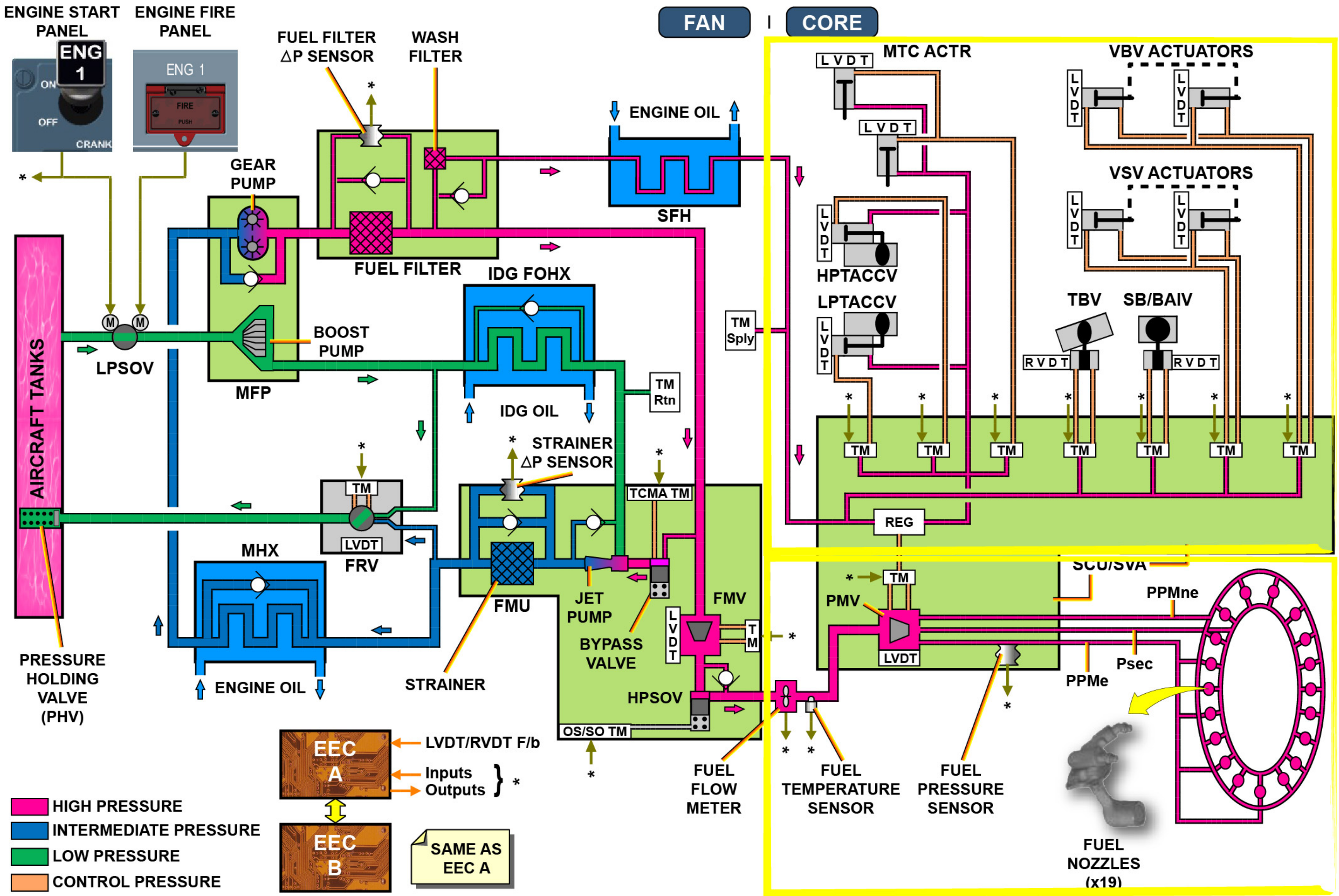
ENGINE FUEL SYSTEM D/O

CORE AREA

The metered HP fuel for combustion is sent from the FMU to the SCU/SVA and monitored by the Fuel Flow Meter and the Fuel Temperature Sensor (FTS) on HP fuel supply line. The Pilot Metering Valve (PMV) within the SCU shares the fuel to the three different manifolds: the Pilot Primary/Main enriched manifold (PPMe), the Pilot Primary/Main non-enriched manifold (PPMne) and the Pilot secondary manifold (Psec). The PMV is controlled by the EEC via its TM and monitored by its LVDT. Fuel split is used to optimize the Twin Annular Premixing Swirler (TAPS) combustor efficiency and emissions according to preset parameters.
The pressure in the PPMe leg is monitored by the Fuel Pressure Sensor.
The HP servo fuel is directed to the seven TMs within the SVA, directly or via the Regulator.
They provide fuel muscle pressure to the Engine Air System actuators: 1 pair for Variable Stator Vane (VSV), 1 pair for Variable Bleed Valve (VBV), 1 pair for Modulated Turbine Cooling (MTC), 1 for High Pressure Turbine Active Clearance Control (HPTACC), 1 for Low Pressure Turbine Active Clearance Control (LPTACC), 1 for Transient Bleed Valve (TBV) and 1 for Start Bleed/Booster Anti-Ice Valve (SB/BAIV).
A pickup on the supply line to the SVA provides the muscle pressure to the three FMU Torque Motors and to the FRV Torque Motor.

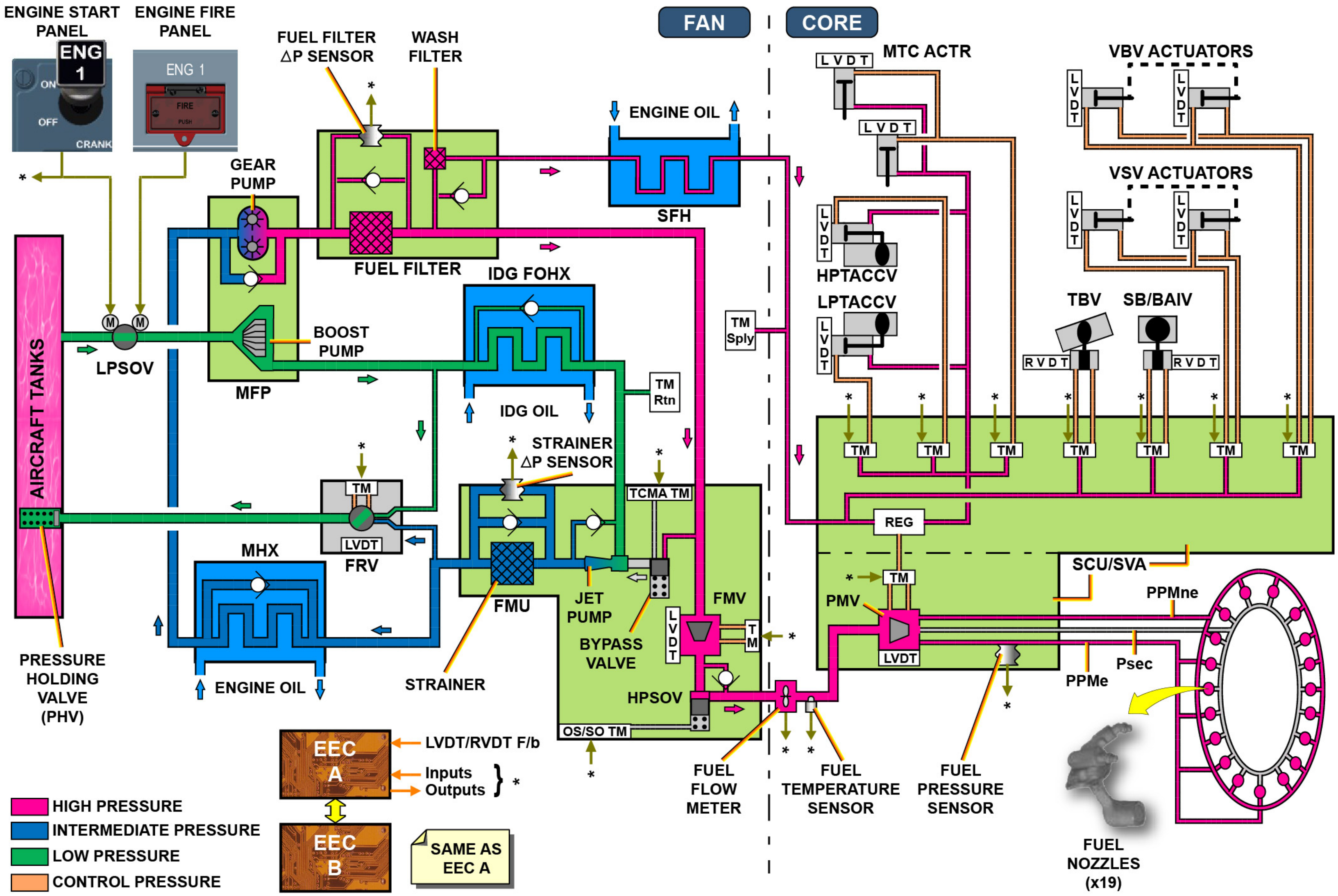

FAN
CORE
ENGINE START PANEL
ENG 1
ON
OFF
CRANK
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
FUEL FILTER ΔP SENSOR
WASH FILTER
ENGINE OIL
SFH
GEAR PUMP
FUEL FILTER
IDG FOHX
IDG OIL
AIRCRAFT TANKS
M
M
LPSOV
BOOST PUMP
MFP
TM Sply
TM Rtn
STRAINER ΔP SENSOR
TCMA TM
TM
LVDT
FRV
MHX
FMU
JET PUMP
BYPASS VALVE
FMV
LVDT
TM
HPSOV
OS/SO TM
STRAINER
PRESSURE HOLDING VALVE (PHV)
ENGINE OIL
EEC A
EEC B
LVDT/RVDT F/b
Inputs
Outputs
SAME AS EEC A
HIGH PRESSURE
INTERMEDIATE PRESSURE
LOW PRESSURE
CONTROL PRESSURE
LVDT
MTC ACTR
VBV ACTUATORS
VSV ACTUATORS
HPTACCV
LPTACCV
TBV
SB/BAIV
RVDT
RVDT
TM
REG
SCU/SVA
PMV
LVDT
PPMne
PPMe
Psec
FUEL FLOW METER
FUEL TEMPERATURE SENSOR
FUEL PRESSURE SENSOR
FUEL NOZZLES (x19)
*

CORE AREA

ENGINE FUEL SYSTEM D/O

STARTING

When the Master Lever is set to ON, the LPSOV opens, the EEC is energized and commands the HPSOV to unlatch via the Over Speed / Shut Off Torque Motor (OS/SO TM).
During starting, the Boost Pump pressurizes the fuel at low pressure and sends it through the IDG FOHX to the FMU. The fuel passes through the Jet Pump and the strainer of the FMU before going through the MHX. At this point, the Gear Pump pressurizes the fuel at high pressure and sends to the Fuel Filter where it is split into fuel for combustion and servo fuel. The fuel for combustion is sent back to the FMU.
The EEC opens the FMV and lets the fuel to flow to the HPSOV which also opens when the pressure is enough and sends fuel to the SCU/SVA via the FFM and the FTS.
The EEC controls the PMV to supply the PPMe and PPMne manifolds up to idle. Above idle, the Psec manifold is also supplied.
In parallel, the servo fuel is sent to the SCU/SVA Regulator and Torque Motors via the SFH.

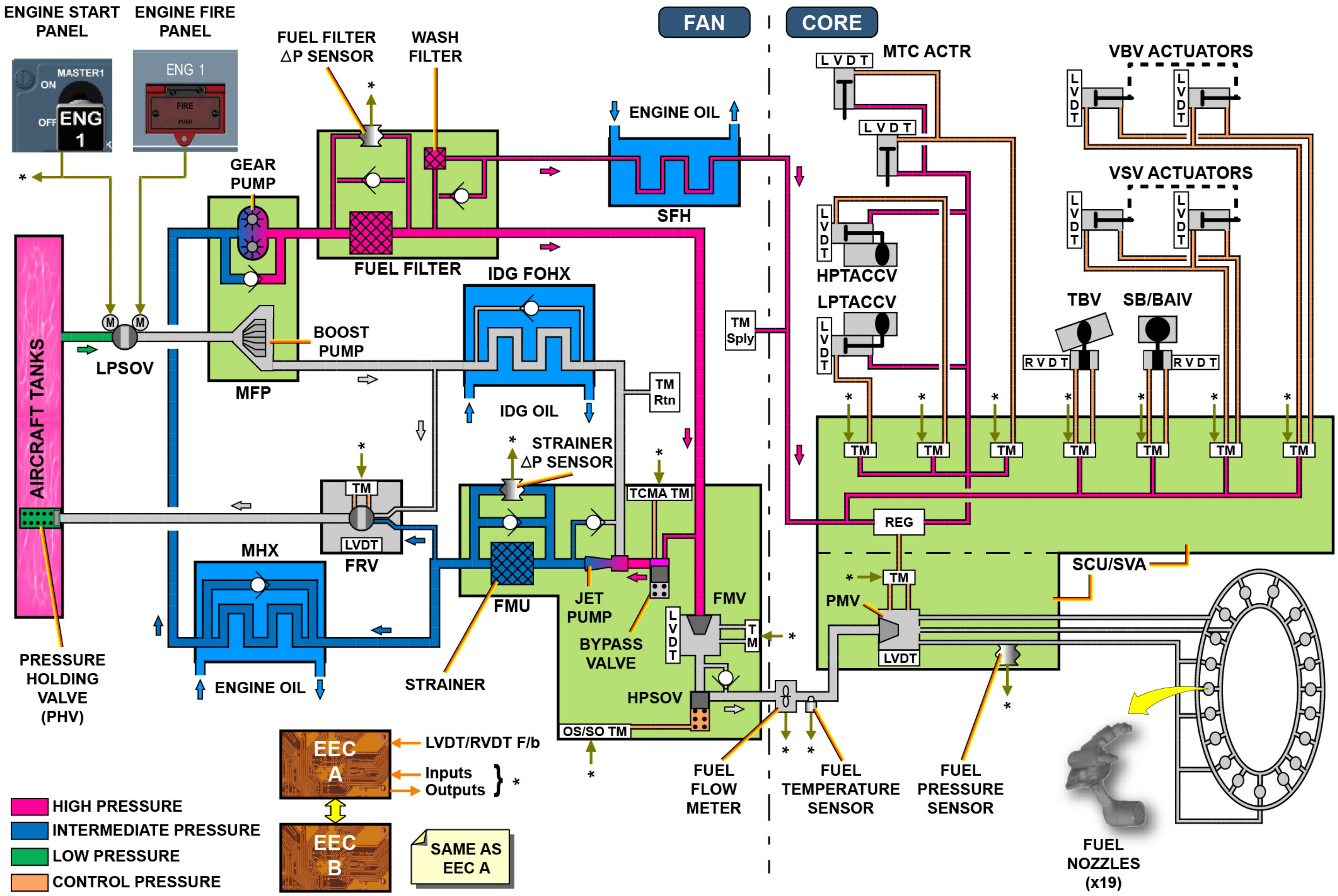

ENGINE START PANEL
ENG 1
ON
OFF
CRANK
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
FUEL FILTER ΔP SENSOR
WASH FILTER
FAN
CORE
MTC ACTR
VBV ACTUATORS
VSV ACTUATORS
LVDT
ENGINE OIL
SFH
GEAR PUMP
FUEL FILTER
IDG FOHX
HPTACCV
LPTACCV
TBV
SB/BAIV
RVDT
AIRCRAFT TANKS
M
LPSOV
BOOST PUMP
MFP
IDG OIL
TM Sply
TM Rtn
TM
STRAINER ΔP SENSOR
TCMA TM
REG
LVDT
FRV
MHX
FMU
JET PUMP
BYPASS VALVE
FMV
HPSOV
OS/SO TM
SCU/SVA
PMV
PPMne
PPMe
Psec
ENGINE OIL
STRAINER
PRESSURE HOLDING VALVE (PHV)
EEC A
EEC B
LVDT/RVDT F/b
Inputs
Outputs
*
SAME AS EEC A
FUEL FLOW METER
FUEL TEMPERATURE SENSOR
FUEL PRESSURE SENSOR
FUEL NOZZLES (x19)
🟥 HIGH PRESSURE
🟦 INTERMEDIATE PRESSURE
🟩 LOW PRESSURE
🟧 CONTROL PRESSURE

STARTING

ENGINE FUEL SYSTEM D/O

SHUTDOWN

NORMAL SHUTDOWN:
During a normal engine shutdown on ground, the Master Lever controls the LPSOV to close and sends a shutdown signal to the EEC.
As a consequence, the EEC first initiates a Thrust Control Malfunction Accommodation (TCMA)/OS Fuel Shutoff test and then activates the SO function to control the HPSOV to close.
The EEC commands the FMV to close ~1.5 seconds after the Master Lever transitions to OFF.
OVERSPEED SHUTDOWN:
Each EEC has two independent switches that monitor the N2 speed. One switch uses the speed signal form the Permanent Magnet Alternator (PMA), while the other switch uses the speed signal from the N2 sensor. Both switches must close to shut down the engine. The overspeed system in both EEC is always active regardless of which EEC is in control.
When an OS condition is detected, both switches are simultaneously activated and lead to a TCMA/OS Fuel Shutoff command causing the HPSOV to close and be hydraulically latched.

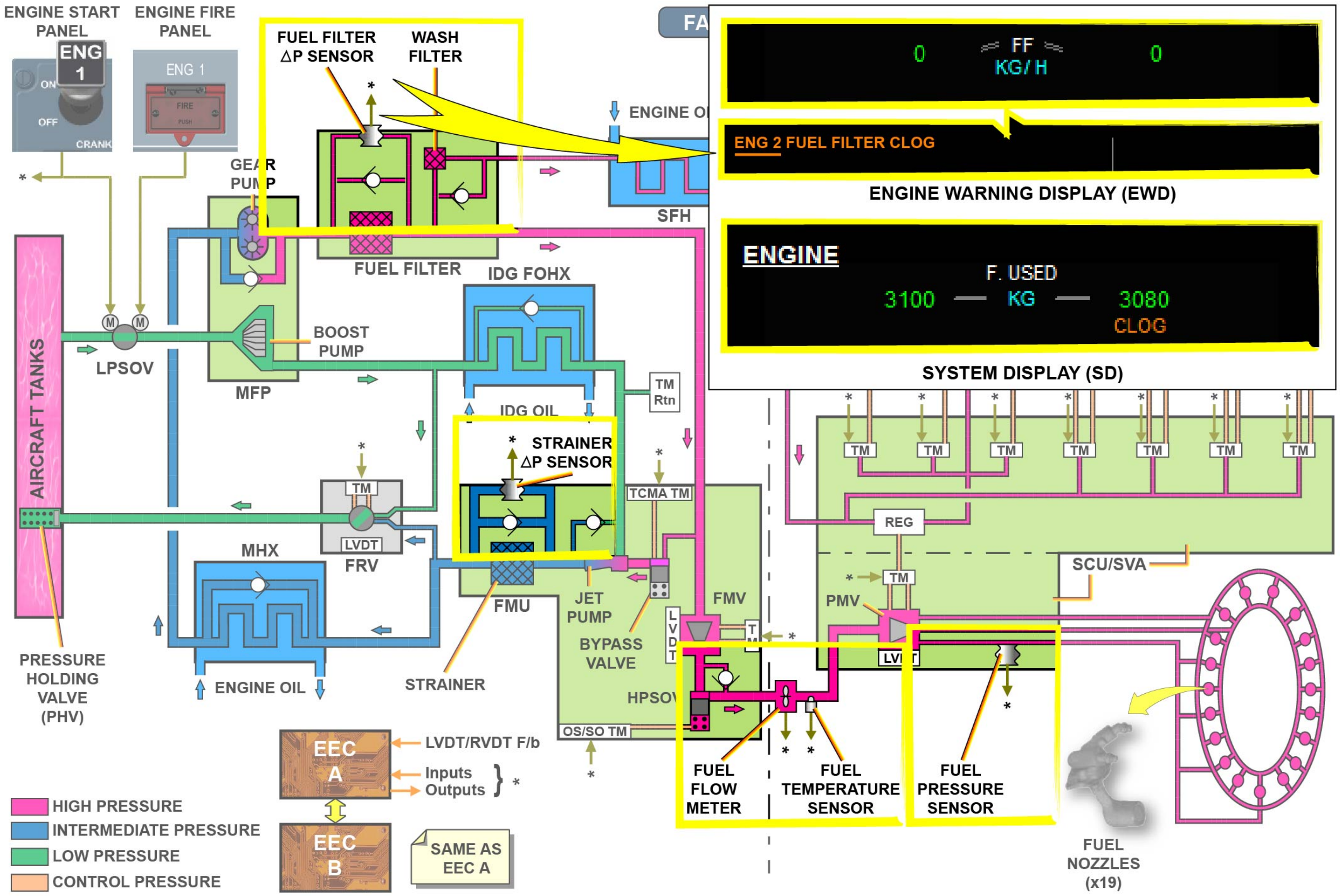

ENGINE START PANEL
MASTER1
ON
OFF
ENG 1
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
FUEL FILTER ΔP SENSOR
WASH FILTER
FAN
CORE
MTC ACTR
VBV ACTUATORS
VSV ACTUATORS
LVDT
ENGINE OIL
SFH
GEAR PUMP
FUEL FILTER
IDG FOHX
HPTACCV
LPTACCV
TBV
SB/BAIV
RVDT
AIRCRAFT TANKS
M
M
LPSOV
BOOST PUMP
MFP
TM Sply
TM Rtn
IDG OIL
STRAINER ΔP SENSOR
TM
TCMA TM
REG
SCU/SVA
MHX
LVDT
FRV
FMU
JET PUMP
FMV
BYPASS VALVE
PMV
LVDT
TM
HPSOV
OS/SO TM
PRESSURE HOLDING VALVE (PHV)
ENGINE OIL
STRAINER
EEC A
EEC B
LVDT/RVDT F/b
Inputs
Outputs
*
SAME AS EEC A
FUEL FLOW METER
FUEL TEMPERATURE SENSOR
FUEL PRESSURE SENSOR
FUEL NOZZLES (x19)
HIGH PRESSURE
INTERMEDIATE PRESSURE
LOW PRESSURE
CONTROL PRESSURE

SHUTDOWN

ENGINE FUEL SYSTEM D/O

FUEL INDICATING

The engine fuel indicating monitors the system condition and provides the system status to the cockpit displays.
The Fuel Flow Meter sends signals to the EECs to compute the fuel flow to the combustor.
The fuel flow is a primary engine parameter and is displayed on the Engine/Warning Display (EWD) permanently. The EEC also sends this data for the fuel used computation and display on the System Display (SD).
The Fuel Filter Differential Pressure (FFDP) sensor measures the differential pressure across the fuel filter.
This helps to detect if the filter is partially or totally clogged.
According to the received value, the EECs will generate various warnings on the EWD: ENG X FUEL FILTER DEGRAD or ENG X FUEL FILTER CLOG or ENG X FUEL SENSOR FAULT and on the SD: CLOG.
The Fuel Strainer Differential Pressure (FSDP) sensor is used to sense the differential pressure across the FMU fuel strainer.
According to the received value, the EECs will generate various warnings on the EWD: ENG X FUEL STRAINER CLOG or ENG X FUEL SENSOR FAULT.
The Fuel Temperature sensor is used by the EECs for the Weight of Fuel Metered (WFM) calculation and for the Fuel Return Valve control.
If it fails, the EECs will generate the following warning on the EWD: ENG X FUEL SENSOR FAULT - TEMP SENSORS.
The Fuel Pressure sensor is used by the EECs to determine the HPSOV, FMV and Bypass Valve position for monitoring, computation and fault annunciation.
If it fails, the EECs will generate the following warning on the EWD: ENG X FADEC SYS FAULT.

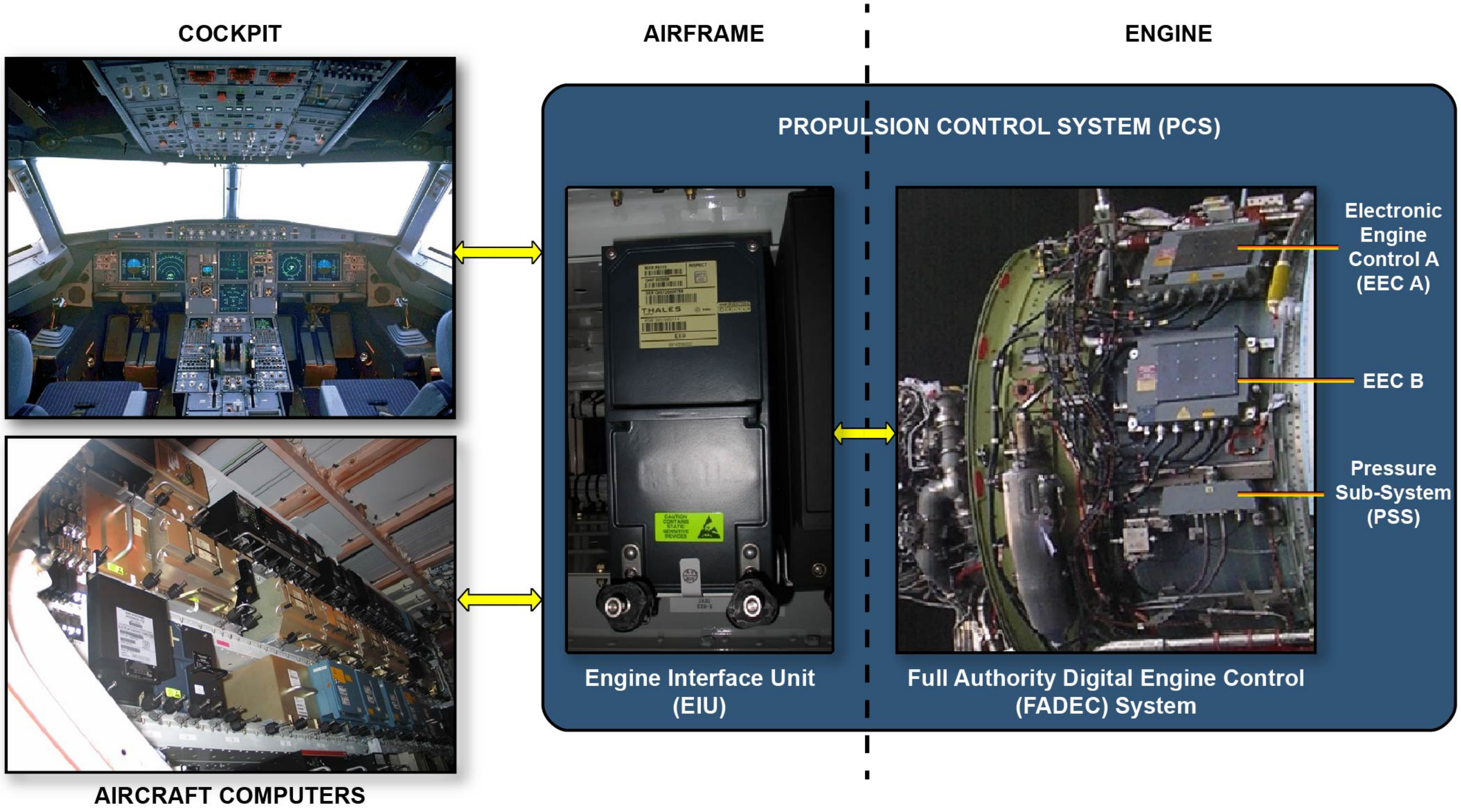

ENGINE START PANEL
ENG 1
ON
OFF
CRANK
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
FUEL FILTER ΔP SENSOR
WASH FILTER
GEAR PUMP
FUEL FILTER
IDG FOHX
ENGINE OIL
SFH
FA
0
FF
KG/H
0
ENG 2 FUEL FILTER CLOG
ENGINE WARNING DISPLAY (EWD)
ENGINE
F. USED
3100
KG
3080
CLOG
SYSTEM DISPLAY (SD)
AIRCRAFT TANKS
LPSOV
M
BOOST PUMP
MFP
IDG OIL
TM Rtn
STRAINER ΔP SENSOR
TCMA TM
TM
LVDT
FRV
MHX
FMU
JET PUMP
BYPASS VALVE
FMV
HPSOV
LVDT
OS/SO TM
STRAINER
ENGINE OIL
PRESSURE HOLDING VALVE (PHV)
REG
SCU/SVA
PMV
LVDT
FUEL FLOW METER
FUEL TEMPERATURE SENSOR
FUEL PRESSURE SENSOR
FUEL NOZZLES (x19)
EEC A
EEC B
LVDT/RVDT F/b
Inputs
Outputs
*
SAME AS EEC A
HIGH PRESSURE
INTERMEDIATE PRESSURE
LOW PRESSURE
CONTROL PRESSURE

FUEL INDICATING

PROPULSION CONTROL SYSTEM (PCS) PRINCIPLE

GENERAL

The Propulsion Control System (PCS) consists in Engine Interface Unit (EIU) and FADEC System which includes 2 Electronic Engine Control (EEC) units and a Pressure Sub-System (PSS) box.
Each EIU is dedicated to an engine. EIU 1 and 2 are located in the aircraft avionics bay 80VU.
The 2 EEC units and PSS are soft mounted using vibration isolators on brackets attached to the engine RH fan case; the EECs are located at the 1 and 2 o'clock positions and the PSS under, at 4 o'clock.


COCKPIT
AIRFRAME
ENGINE
PROPULSION CONTROL SYSTEM (PCS)
Electronic Engine Control A (EEC A)
EEC B
Pressure Sub-System (PSS)
Engine Interface Unit (EIU)
Full Authority Digital Engine Control (FADEC) System
AIRCRAFT COMPUTERS

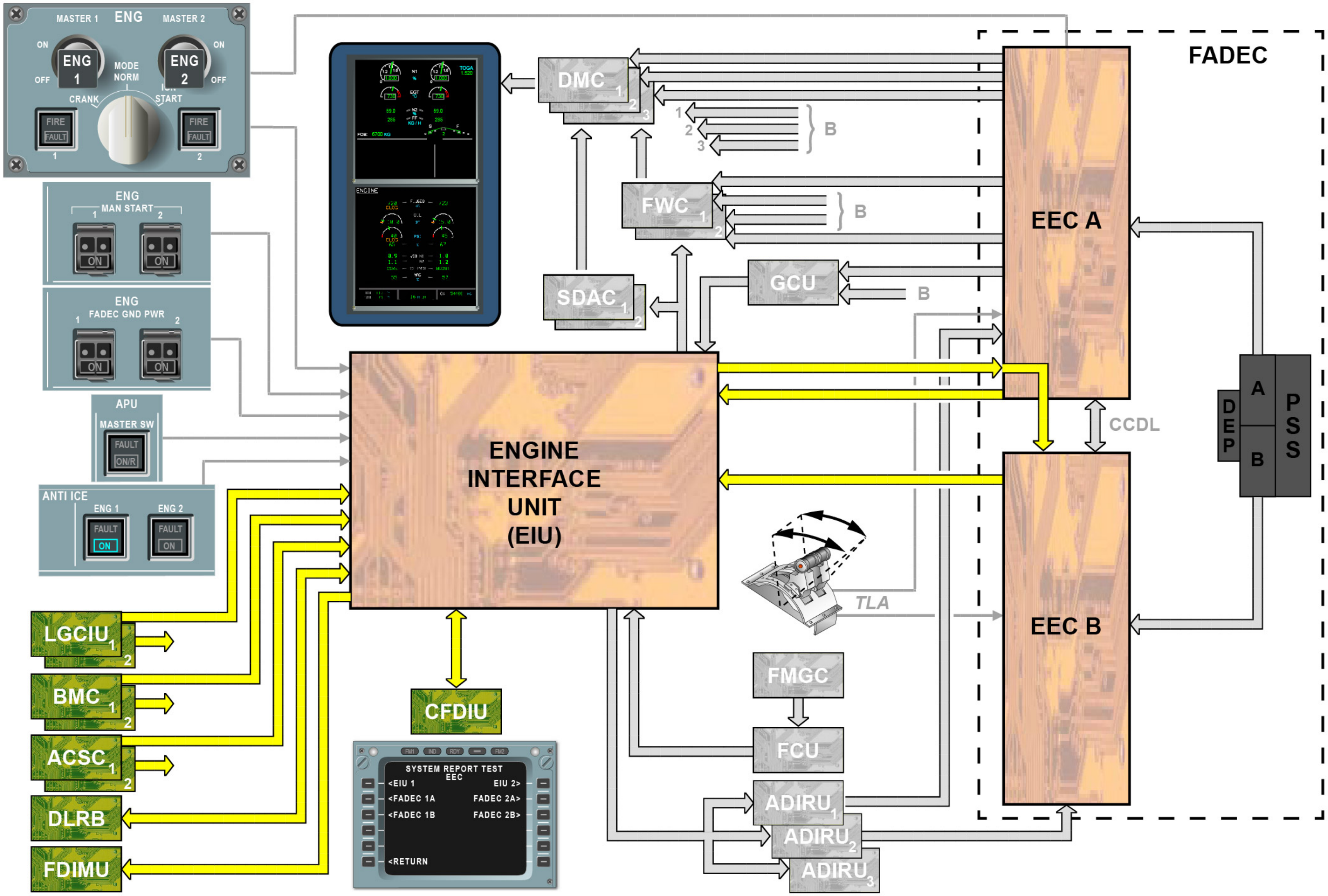
GENERAL

PROPULSION CONTROL SYSTEM (PCS) PRINCIPLE

ENGINE INTERFACE UNIT

There are 2 EIUs per aircraft, one per engine.
The EIU ensures the segregation of the 2 engines and aircraft electrical power supply to the FADEC.
Each EIU is an interface concentrator between the airframe and the corresponding Engine EEC A & EEC B.
There is a single EIU input into the EEC A cross connected to EEC B but both EECs transfer engine data to the EIU.
If EEC A fails, EEC B receives airframe input through the cross channel data link.
The EIU concentrates data from or to the cockpit panels and displays (also Flaps and slats lever position).
It gives logics and information to or from other aircraft systems such as:
- Flight/Ground from the Landing Gear Control and Interface Unit (LGCIU),
- Environmental Control System (ECS) pressure demand from the Air,
- Conditioning System Controllers (ACSCs),
- Bleed Monitoring Computers (BMCs) for Engine Bleed status information,
- Data Loading Routing Box (DLRB) for software uploads,
- Flight Data Interface Management Unit (FDIMU) for flight data recording.

For engine maintenance, the PCS is connected to the Centralized Fault Display System (CFDIU) and Multipurpose Control Display Unit (MCDU) for BITE information via the EIU.
The EIU is energized as soon as the aircraft electrical network is energized. The EIU is dispatch critical.


ENG
MASTER 1
MASTER 2
ON
OFF
ENG 1
ENG 2
MODE
NORM
CRANK
IGN START
FIRE
FAULT
1
2
ENG
MAN START
ON
ENG
FADEC GND PWR
ON
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG 1
ENG 2
FAULT
ON
DMC 1 2 3
FWC 1 2
SDAC 1 2
GCU
B
1
2
3
FADEC
EEC A
EEC B
CCDL
DEP
A
B
PSS
ENGINE INTERFACE UNIT (EIU)
TLA
FMGC
FCU
ADIRU 1
ADIRU 2
ADIRU 3
CFDIU
LGCIU 1 2
BMC 1 2
ACSC 1 2
DLRB
FDIMU
SYSTEM REPORT TEST
EEC
<EIU 1
EIU 2>
<FADEC 1A
FADEC 2A>
<FADEC 1B
FADEC 2B>
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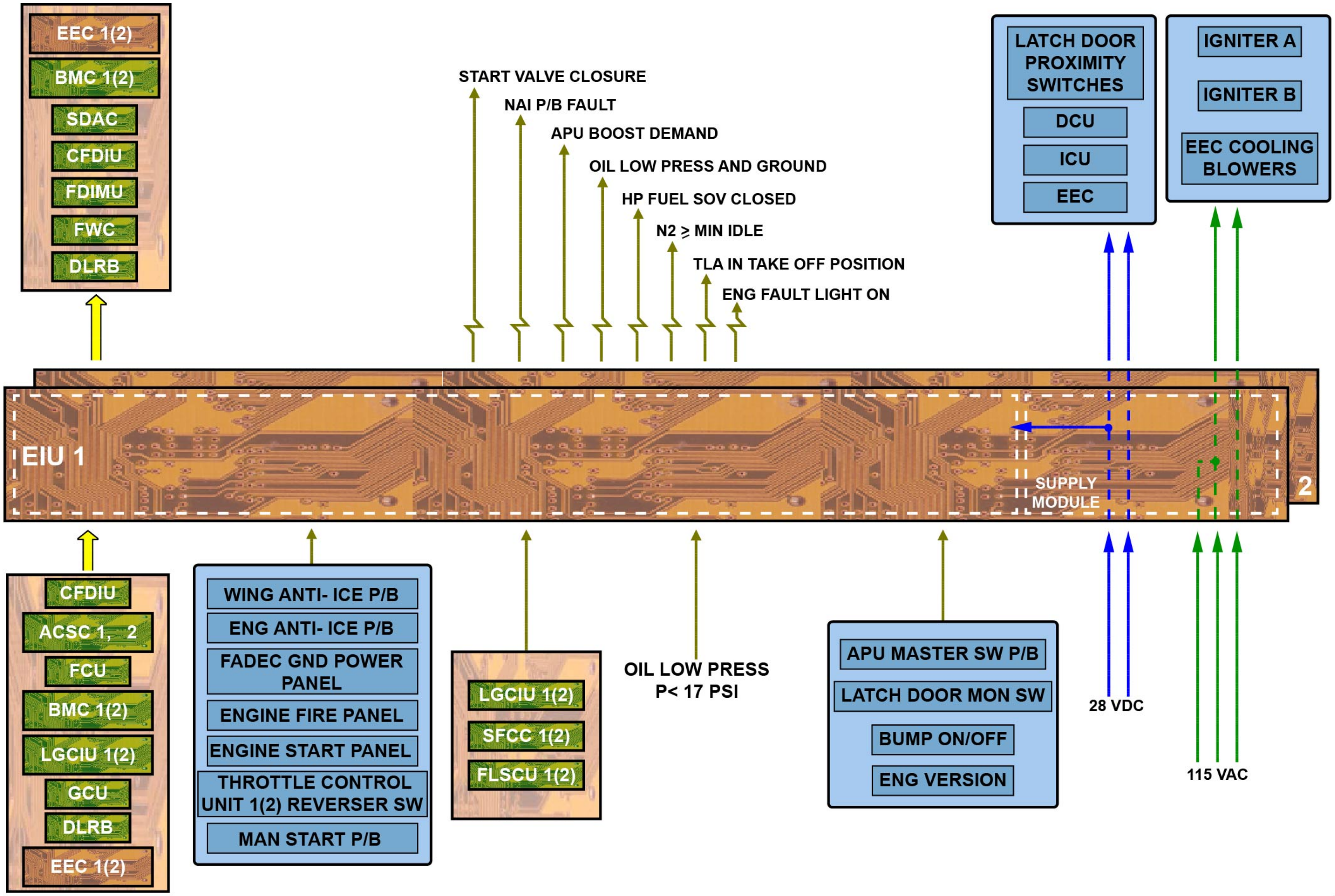
ENGINE INTERFACE UNIT


EEC 1(2)
BMC 1(2)
SDAC
CFDIU
FDIMU
FWC
DLRB
START VALVE CLOSURE
NAI P/B FAULT
APU BOOST DEMAND
OIL LOW PRESS AND GROUND
HP FUEL SOV CLOSED
N2 ≥ MIN IDLE
TLA IN TAKE OFF POSITION
ENG FAULT LIGHT ON
LATCH DOOR PROXIMITY SWITCHES
DCU
ICU
EEC
IGNITER A
IGNITER B
EEC COOLING BLOWERS
EIU 1
SUPPLY MODULE
2
CFDIU
ACSC 1, 2
FCU
BMC 1(2)
LGCIU 1(2)
GCU
DLRB
EEC 1(2)
WING ANTI- ICE P/B
ENG ANTI- ICE P/B
FADEC GND POWER PANEL
ENGINE FIRE PANEL
ENGINE START PANEL
THROTTLE CONTROL UNIT 1(2) REVERSER SW
MAN START P/B
LGCIU 1(2)
SFCC 1(2)
FLSCU 1(2)
OIL LOW PRESS P< 17 PSI
APU MASTER SW P/B
LATCH DOOR MON SW
BUMP ON/OFF
ENG VERSION
28 VDC
115 VAC

ENGINE INTERFACE UNIT

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PROPULSION CONTROL SYSTEM (PCS) PRINCIPLE

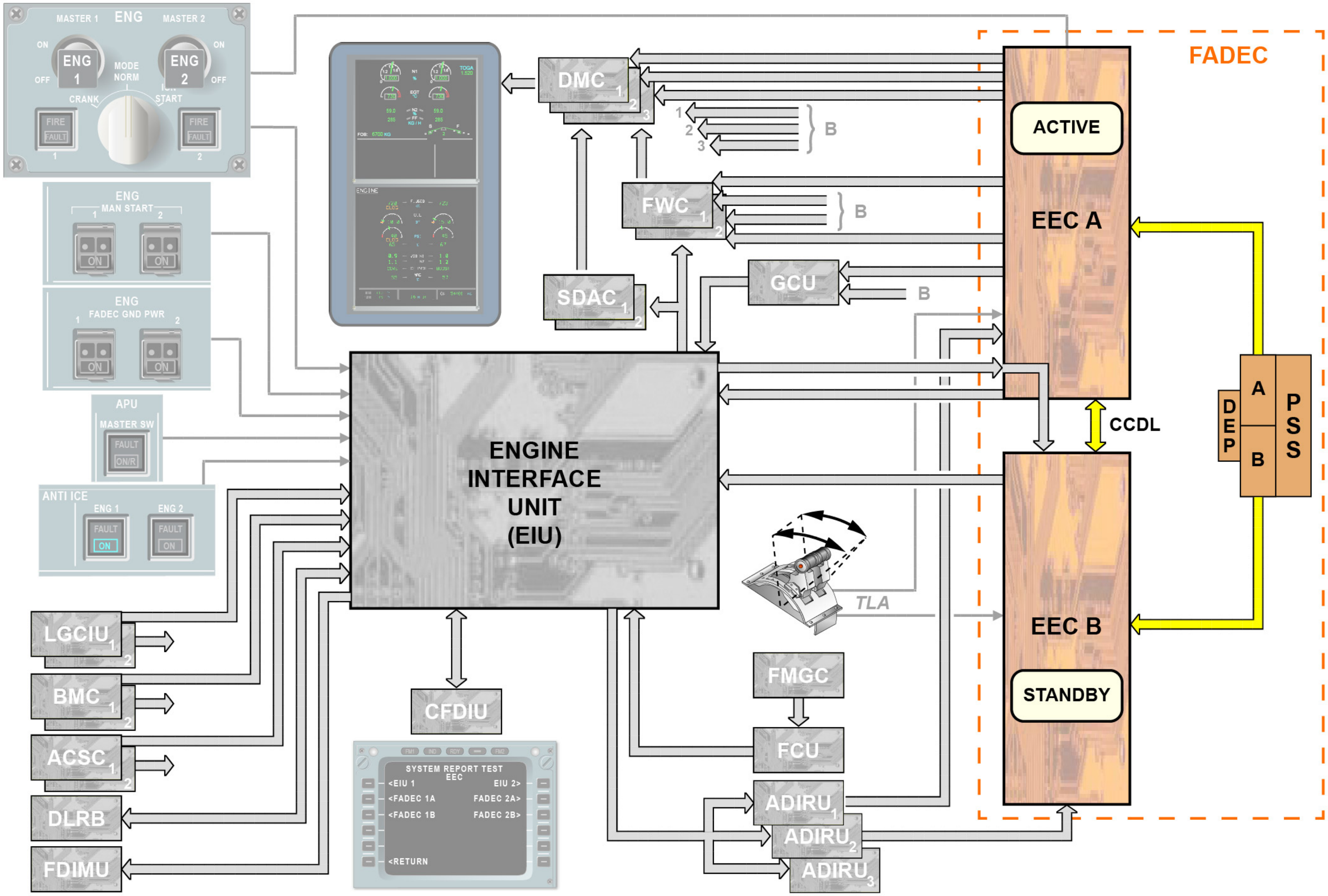
FADEC

EECs

On each engine, the FADEC consists in a two EECs: A and B with crosstalk, a PSS and sensors used for control and monitoring.
Each EEC, channel A and channel B, has the capability to control the engine systems based upon the Throttle Level Angle (TLA) from the aircraft.
Only one EEC at a time will operate the engine valves, actuators and solenoids. This EEC is called the "channel in control" or the "active channel." The other EEC will be "standby" or "inactive."
The EEC in control switches during engine start if equally healthy.

PSS

The PSS receives engine air pressure measurements and converts them into electrical signals to both EECs for engine control and monitoring.
The Data Entry Plug (DEP) attached to the engine is connected to the PSS, thus communicated to the EECs.


ENG
MASTER 1
MASTER 2
ON
OFF
ENG 1
ENG 2
MODE
NORM
CRANK
IGN START
FIRE FAULT
1
2
ENG MAN START
ON
ENG FADEC GND PWR
APU MASTER SW
FAULT
ON/R
ANTI ICE
ENG 1
ENG 2
DMC 1 2 3
FWC 1 2
SDAC 1 2
GCU
B
1
2
3
FADEC
ACTIVE
EEC A
CCDL
DEP
A
B
PSS
EEC B
STANDBY
ENGINE INTERFACE UNIT (EIU)
TLA
LGCIU 1 2
BMC 1 2
ACSC 1 2
DLRB
FDIMU
CFDIU
FMGC
FCU
ADIRU 1
ADIRU 2
ADIRU 3
SYSTEM REPORT TEST
EEC
<EIU 1
EIU 2>
<FADEC 1A
FADEC 2A>
<FADEC 1B
FADEC 2B>
<RETURN

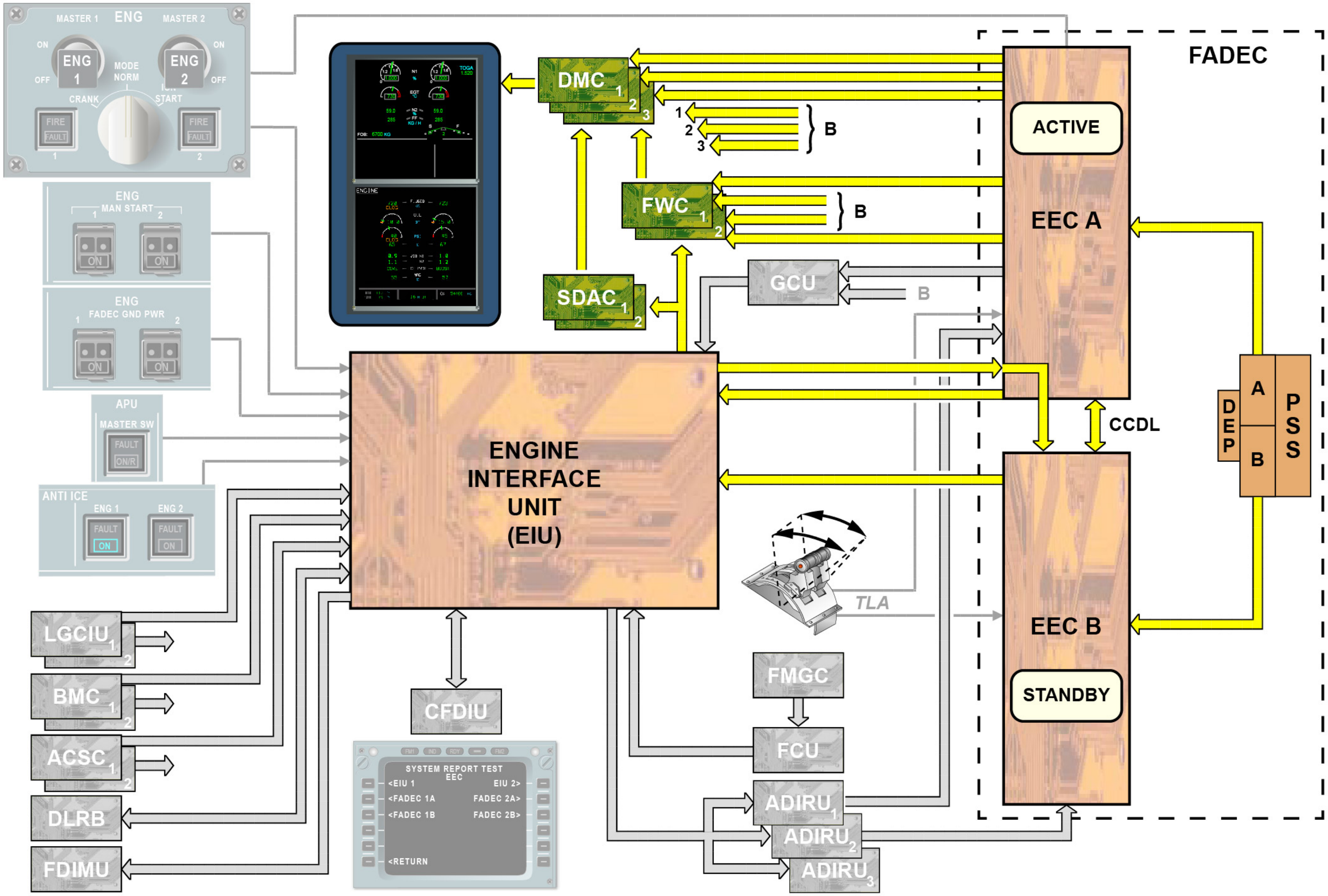
FADEC - EECS & PSS

PROPULSION CONTROL SYSTEM (PCS) PRINCIPLE

FADEC (continued)

PARAMETERS

The primary parameters (N1, N2, Exhaust Gas Temperature (EGT) and Fuel Flow (FF)) are sent by the EEC to the ECAM through Display Management Computers (DMCs).
The Engine system page shows secondary parameters: oil quantity, pressure, temperature and vibrations.
The Flight Warning System (FWS) will gather necessary information directly from EEC, EIU, System Data Acquisition Concentrator (SDAC) and generates associated messages on Engine/Warning Display (EWD).


MASTER 1
ENG
MASTER 2
ON
OFF
ENG 1
MODE NORM
ENG 2
CRANK
IGN START
FIRE FAULT
1
2
ENG MAN START
1
2
ON
ENG FADEC GND PWR
1
2
ON
APU MASTER SW
FAULT
ON/R
ANTI ICE
ENG 1
ENG 2
FAULT
ON
DMC 1 2 3
1
2
3
B
FWC 1 2
B
SDAC 1 2
GCU
B
FADEC
ACTIVE
EEC A
CCDL
EEC B
STANDBY
A
B
DEP
PSS
ENGINE INTERFACE UNIT (EIU)
TLA
LGCIU 1 2
BMC 1 2
ACSC 1 2
DLRB
FDIMU
CFDIU
SYSTEM REPORT TEST
EEC
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EIU 2>
<FADEC 1A
FADEC 2A>
<FADEC 1B
FADEC 2B>
<RETURN
FMGC
FCU
ADIRU 1
ADIRU 2
ADIRU 3

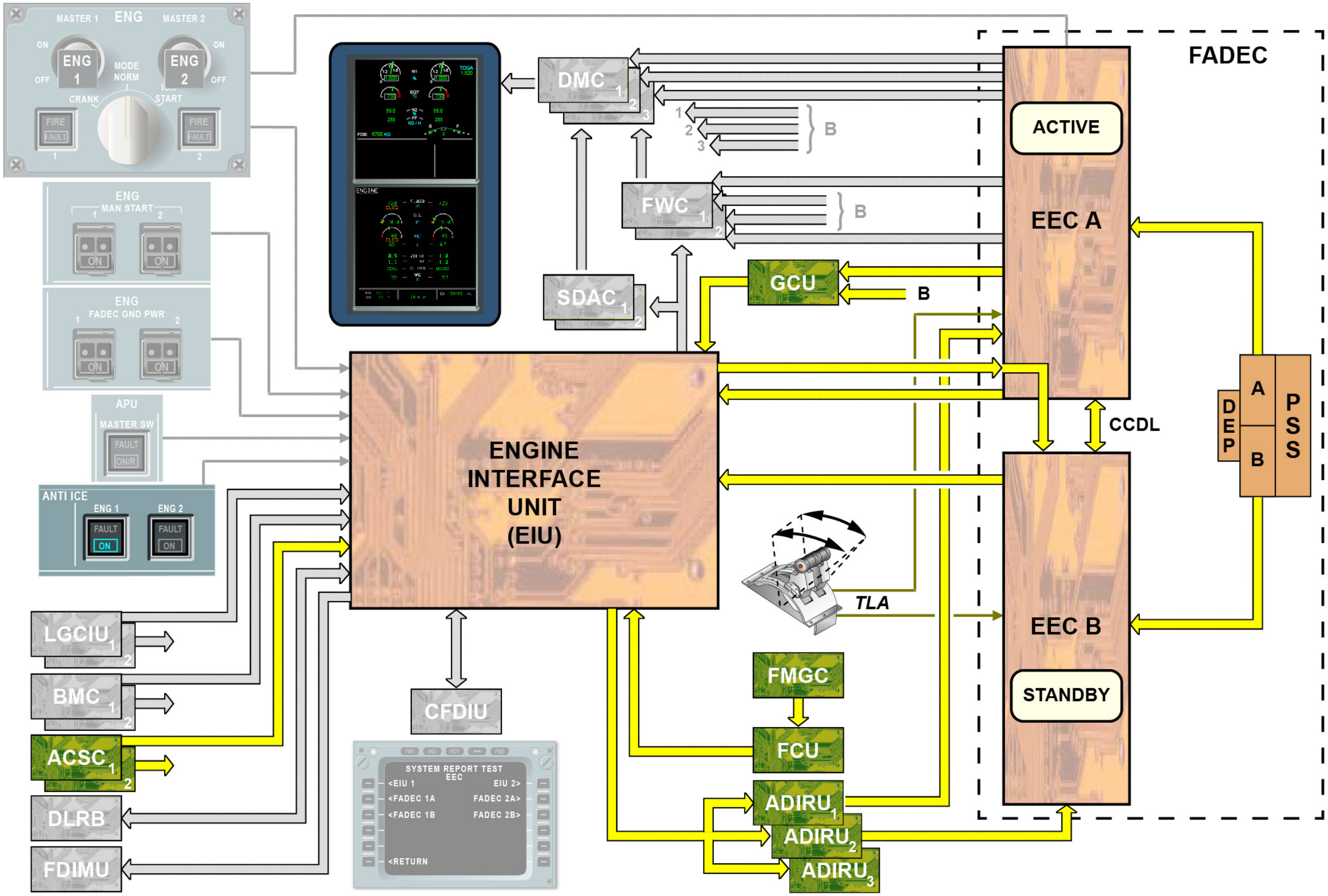
FADEC - PARAMETERS

PROPULSION CONTROL SYSTEM (PCS) PRINCIPLE

POWER MANAGEMENT

The FADEC system manages the engine thrust and optimizes the performance.
The EEC uses air data parameters from Air Data/Inertial Reference System (ADIRS) for rating calculations.
The FADEC manages power according to two thrust modes:
- manual mode depending on TLA,
- automatic thrust mode depending on autothrust function generated by the Auto Flight System (AFS = FMGC/FCU).

The FADEC also provides two idle mode selections: minimum idle and approach idle.
If the aircraft is on ground and extend the slats the engine will stay at minimum idle but in flight it will go to approach idle. The idle can also be modulated up to approach idle depending on: Air conditioning demand, wing anti-ice demand, engine anti-ice demand and oil temperature (for Integrated Drive Generator (IDG) cooling).
EEC needs to receive the EPGS Load from GCU for engine performance optimization and the EEC provides speed information to the Generator Control Unit (GCU) for Under-Speed (US) set point, control and protection.


MASTER 1
ENG
MASTER 2
ON
OFF
ENG 1
MODE
NORM
ENG 2
CRANK
IGN START
FIRE
FAULT
1
2
ENG
MAN START
1
2
ON
ENG
FADEC GND PWR
1
2
ON
APU
MASTER SW
FAULT
ON/R
ANTI ICE
ENG 1
ENG 2
FAULT
ON
LGCIU 1 2
BMC 1 2
ACSC 1 2
DLRB
FDIMU
DMC 1 2 3
1
2
3
B
FWC 1 2
B
SDAC 1 2
GCU
B
ENGINE INTERFACE UNIT (EIU)
CFDIU
SYSTEM REPORT TEST
EEC
<EIU 1
EIU 2>
<FADEC 1A
FADEC 2A>
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TLA
FMGC
FCU
ADIRU 1
ADIRU 2
ADIRU 3
FADEC
ACTIVE
EEC A
CCDL
EEC B
STANDBY
DEP
A
B
PSS

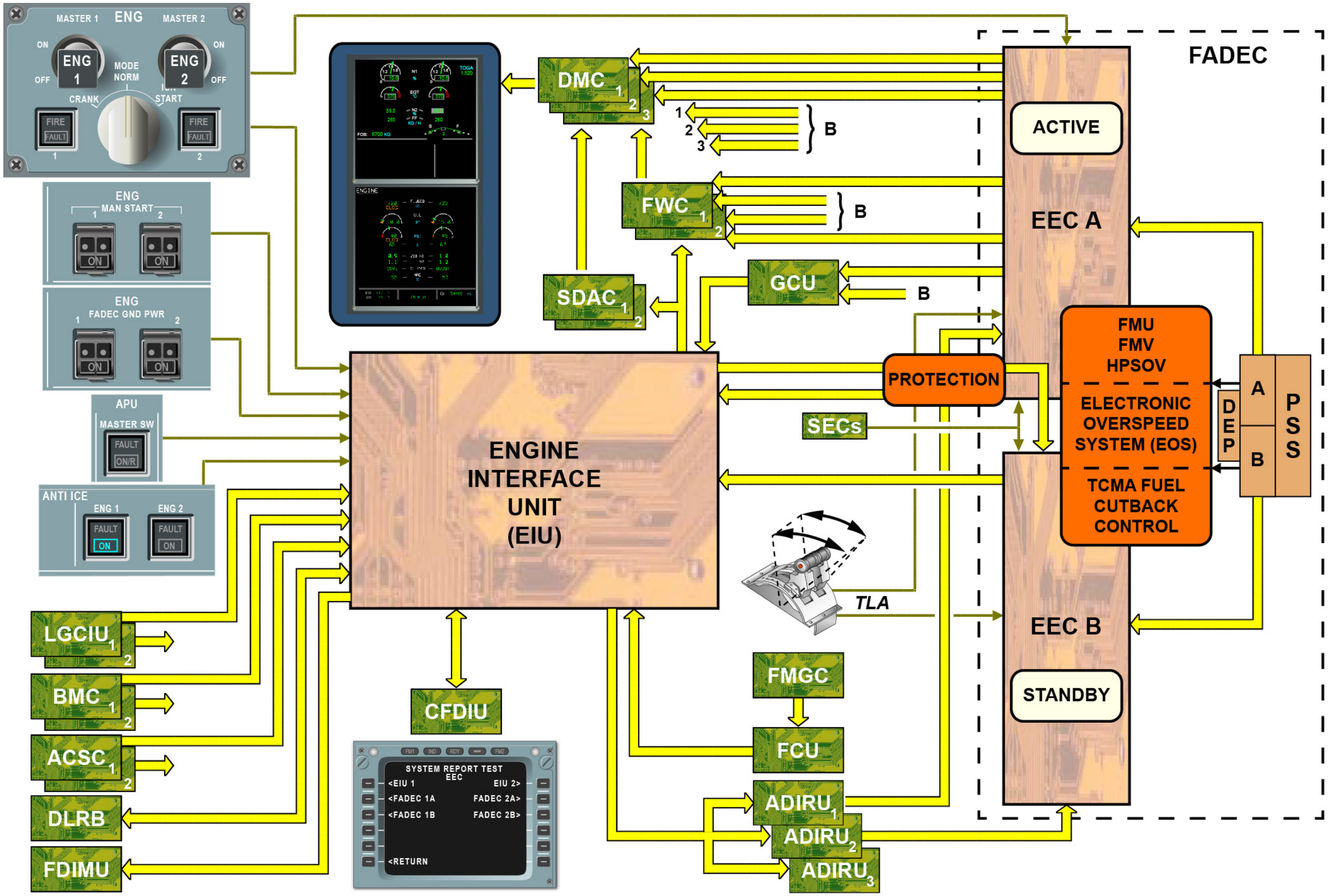
POWER MANAGEMENT

PROPULSION CONTROL SYSTEM (PCS) PRINCIPLE

ENGINE LIMIT PROTECTION

The FADEC provides thrust parameter limit computation thus ensuring engine integrity protection.
The FADEC system incorporates hardware and/or software limits to prevent over-boosting or overspeed of the engine. Limit protection is provided for fan speed, core speed, fuel flow and combustor pressure.
In addition, during sub-idle operation, the FADEC system will prevent the engine from exceeding starting EGT temperature limits.
The TCMA logic on the LEAP-1A engine identifies if the engine is not responding the throttle command and takes mitigating action if required.
In case of a Thrust Control Malfunction (TCM) event, the TCMA reduces the thrust by reducing the quantity of metered fuel flow or shut-down the engine on ground (HPSOV closed) as commanded by the EEC.
A TCM Overthrust event may be caused by the following:
- The throttle lever assembly,
- The throttle lever position resolvers,
- A spurious EEC command to the Fuel Metering Valve (FMV),
- A physical failure of the FMV.

A loss of TCMA shutoff capability is detected when the relay controlled by the Spoiler and Elevator Computer (SEC) is Failed Open.


MASTER 1
ENG
MASTER 2
ON
OFF
ENG 1
MODE NORM
ENG 2
CRANK
IGN START
FIRE FAULT
ENG MAN START
1
2
ON
ENG FADEC GND PWR
APU MASTER SW
FAULT
ON/R
ANTI ICE
ENG 1
ENG 2
LGCIU 1 2
BMC 1 2
ACSC 1 2
DLRB
FDIMU
DMC 1 2 3
FWC 1 2
SDAC 1 2
GCU
B
SECs
ENGINE INTERFACE UNIT (EIU)
CFDIU
FM1
IND
RDY
FM2
SYSTEM REPORT TEST
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EIU 2>
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FADEC 2A>
<FADEC 1B
FADEC 2B>
<RETURN
TLA
FMGC
FCU
ADIRU 1
ADIRU 2
ADIRU 3
PROTECTION
FADEC
ACTIVE
EEC A
FMU
FMV
HPSOV
ELECTRONIC OVERSPEED SYSTEM (EOS)
TCMA FUEL CUTBACK CONTROL
DEP
A
B
PSS
EEC B
STANDBY

ENGINE LIMIT PROTECTION

PROPULSION CONTROL SYSTEM (PCS) PRINCIPLE

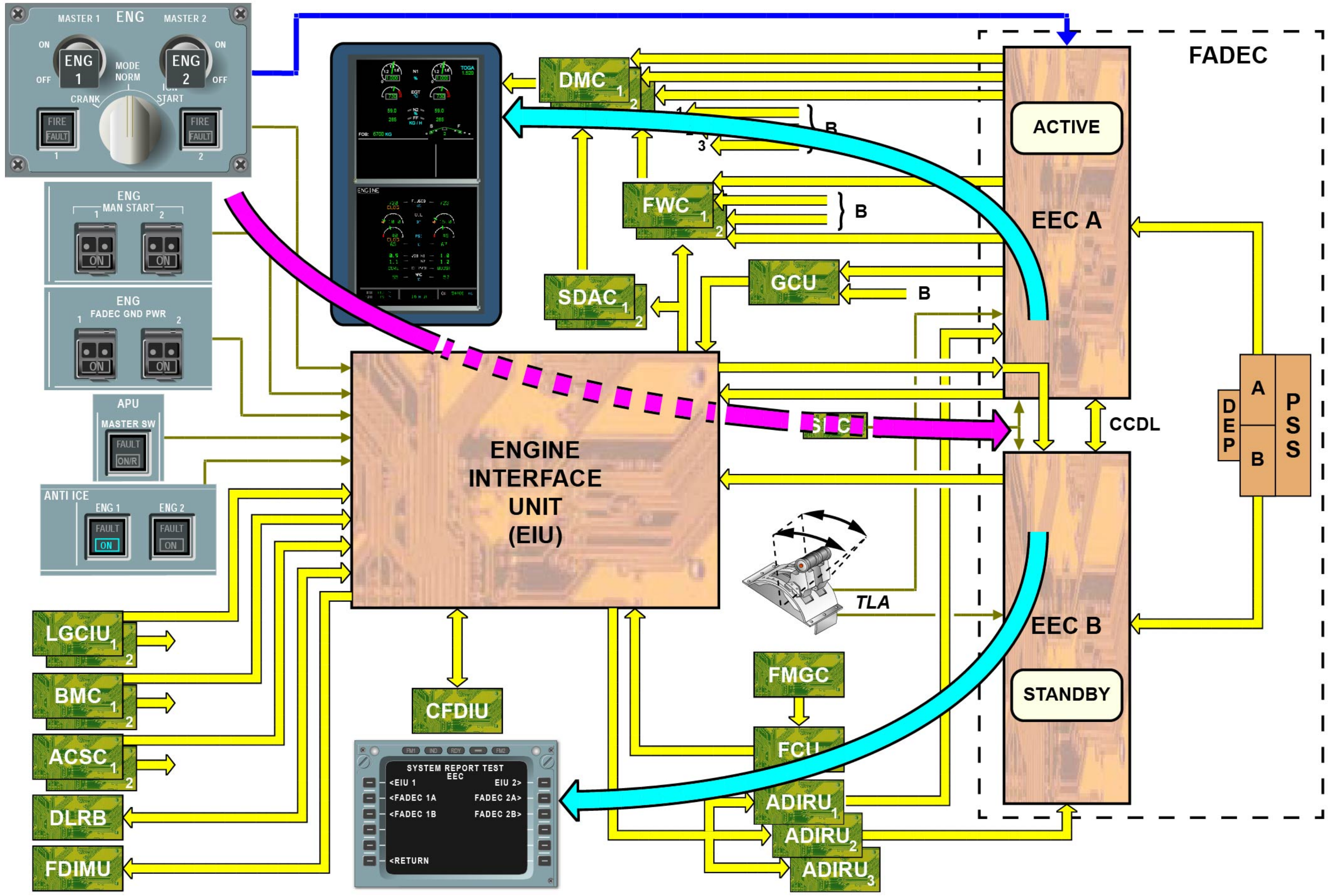
ENGINE SYSTEM CONTROL

STARTING AND IGNITION

The FADEC controls the engine start sequence in automatic or manual mode when initiated from the control panels; those signals are transmitted via the EIU. But there is a direct discrete input to the EEC from the Master Switch OFF position.
The EECs monitor N1, N2, EGT and oil parameters and then can abort or recycle an engine start.

ENGINE SUB-SYSTEMS

The FADEC provides optimal engine operation in compatibility with Aircraft Systems by controlling:
- combustor metering valve and fuel flow,
- compressor airflow and turbine case cooling,
- forward and Reverse thrust settings; the Reverser Tertiary Lock System switching control is performed by the SEC,
- thermal management (oil cooling, fuel heating),
- control and monitoring sensors,
- BITE (fault detection, isolation, annunciation and transmission to the aircraft),
- nacelle anti-ice.


MASTER 1
ENG
MASTER 2
ON
OFF
ENG 1
MODE
NORM
CRANK
IGN START
ENG 2
FIRE
FAULT
ENG MAN START
1
2
ON
ENG FADEC GND PWR
APU MASTER SW
FAULT
ON/R
ANTI ICE
ENG 1
ENG 2
ON
DMC 1 2
FWC 1 2
SDAC 1 2
GCU
B
1
3
ENGINE INTERFACE UNIT (EIU)
SEC
FADEC
ACTIVE
EEC A
EEC B
STANDBY
CCDL
DEP
A
B
PSS
TLA
FMGC
FCU
ADIRU 1
ADIRU 2
ADIRU 3
CFDIU
LGCIU 1 2
BMC 1 2
ACSC 1 2
DLRB
FDIMU
SYSTEM REPORT TEST
EEC
<EIU 1
EIU 2>
<FADEC 1A
FADEC 2A>
<FADEC 1B
FADEC 2B>
<RETURN

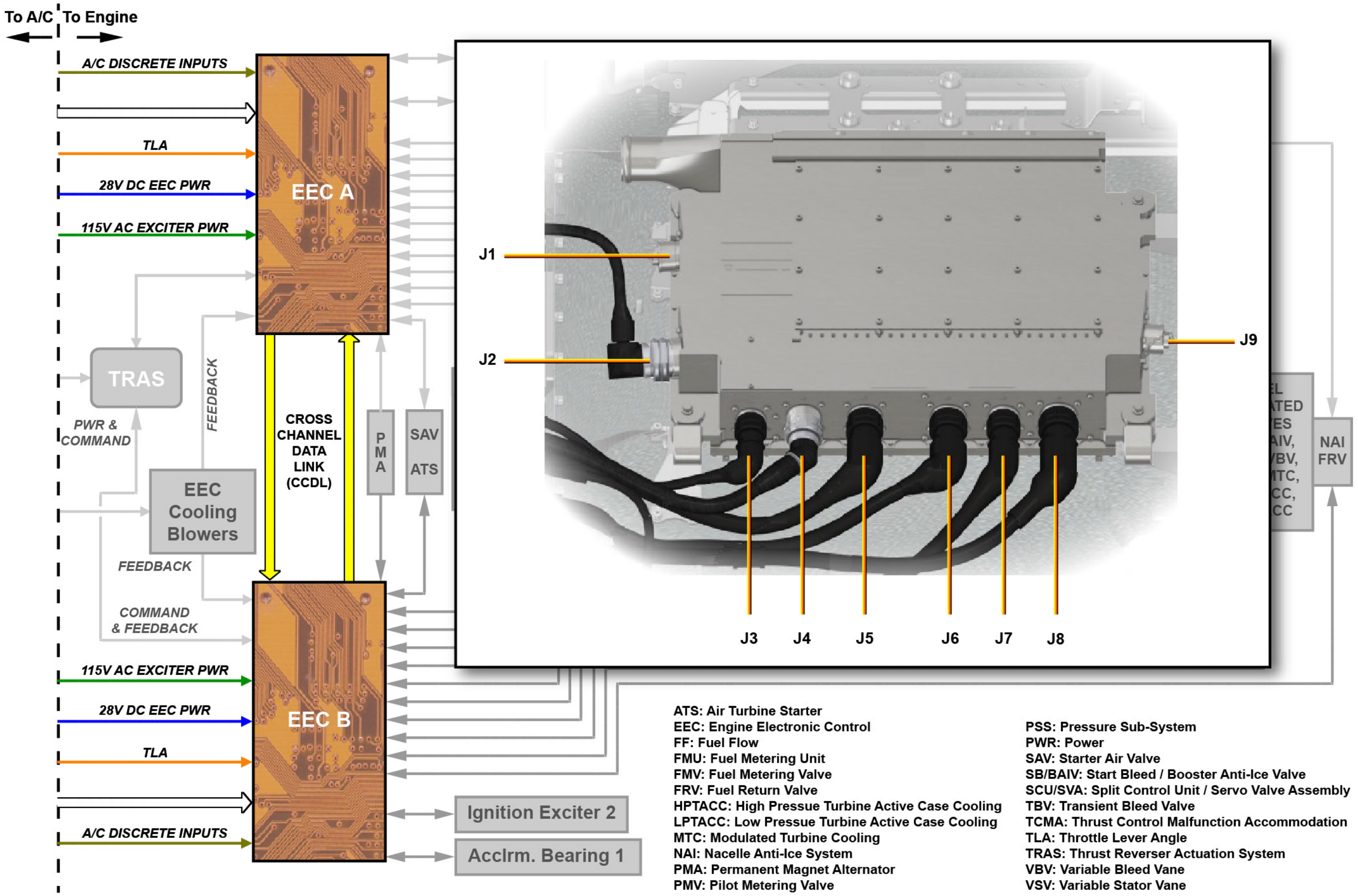
ENGINE SYSTEM CONTROL - STARTING AND IGNITION & ENGINE SUB-SYSTEMS

FADEC INTERFACES

EEC

Two Engine Electronic Control (EEC) units form the brain of the Full Authority Digital Engine Control (FADEC): EEC A and EEC B.
FADEC inputs or outputs are transmitted on a digital, analog or discrete format.
The 2 EECs exchange data externally using a Cross Channel Data Link (CCDL).
Any time the engine is operating and both EECs are equally healthy; each EEC is constantly monitoring the inputs of the Pressure Sub-System (PSS) box, engine sensors, probes, position feedbacks, thrust reverser, and aircraft inputs.
Each EEC also monitors its own outputs and internal operation for proper operation.
Each EEC unit has 9 connectors:

- J1 not used,
- J2 & J4 for data exchange with A/C,
- J3 for the Permanent Magnet Alternator (PMA),
- J5 to J8 for data exchange with engine components,
- J9 used for ground test (capped during normal engine operation).


To A/C
To Engine
A/C DISCRETE INPUTS
TLA
28V DC EEC PWR
115V AC EXCITER PWR
EEC A
TRAS
PWR & COMMAND
FEEDBACK
EEC Cooling Blowers
FEEDBACK
COMMAND & FEEDBACK
CROSS CHANNEL DATA LINK (CCDL)
PMA
SAV
ATS
J1
J2
J9
J3
J4
J5
J6
J7
J8
EL
ATED
ES
AIV,
VBV,
MTC,
CC,
CC
NAI
FRV
115V AC EXCITER PWR
28V DC EEC PWR
TLA
A/C DISCRETE INPUTS
EEC B
Ignition Exciter 2
Acclrm. Bearing 1

ATS: Air Turbine Starter
EEC: Engine Electronic Control
FF: Fuel Flow
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
FRV: Fuel Return Valve
HPTACC: High Pressue Turbine Active Case Cooling
LPTACC: Low Pressue Turbine Active Case Cooling
MTC: Modulated Turbine Cooling
NAI: Nacelle Anti-Ice System
PMA: Permanent Magnet Alternator
PMV: Pilot Metering Valve
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SAV: Starter Air Valve
SB/BAIV: Start Bleed / Booster Anti-Ice Valve
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TLA: Throttle Lever Angle
TRAS: Thrust Reverser Actuation System
VBV: Variable Bleed Vane
VSV: Variable Stator Vane

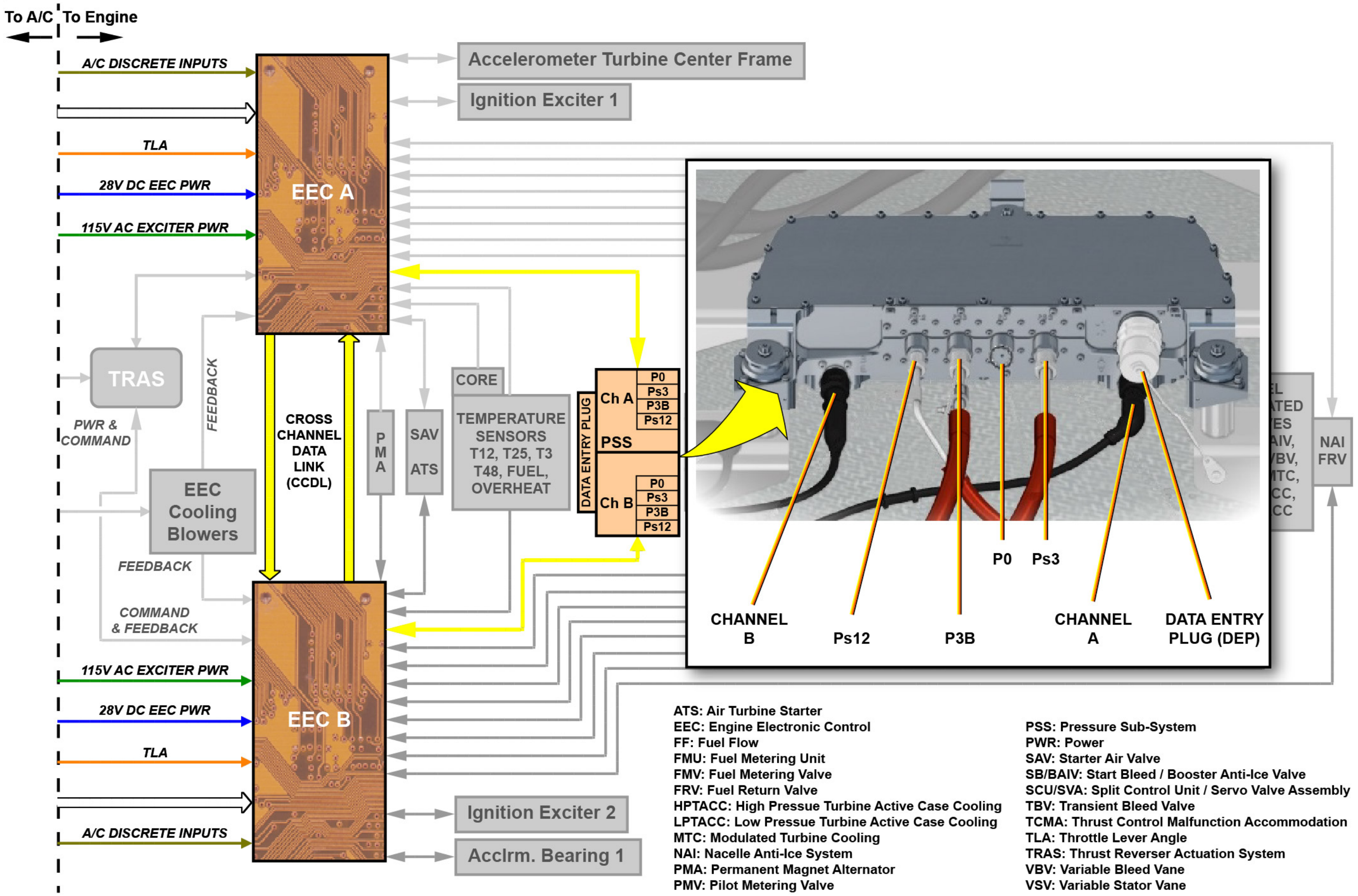
EEC

FADEC INTERFACES

PSS

The PSS main function is to perform signal conversions of the pressure system inputs and communicate with each EEC.
Its second function is to provide CCDL backup.
The PSS is a dual channel electronic unit which provides pneumatic pressure inputs for sensing:
- ambient air pressure (P0),
- compressor bleed pressure (P3B),
- compressor discharge pressure (PS3),
- and fan inlet pressure (PS12).

The Data Entry Plug (DEP) provides engine rating, thrust bump and N1 trim levels.
Each EEC (channel A and channel B) "reads" the plug settings during power-up initialization only, and the setting for each discrete is latched.


To A/C
To Engine
A/C DISCRETE INPUTS
TLA
28V DC EEC PWR
115V AC EXCITER PWR
EEC A
Accelerometer Turbine Center Frame
Ignition Exciter 1
TRAS
PWR & COMMAND
FEEDBACK
EEC Cooling Blowers
FEEDBACK
COMMAND & FEEDBACK
CROSS CHANNEL DATA LINK (CCDL)
P M A
SAV
ATS
CORE
TEMPERATURE SENSORS T12, T25, T3 T48, FUEL, OVERHEAT
DATA ENTRY PLUG
Ch A
P0
Ps3
P3B
Ps12
PSS
Ch B
P0
Ps3
P3B
Ps12
CHANNEL B
Ps12
P3B
P0
Ps3
CHANNEL A
DATA ENTRY PLUG (DEP)
EL
ATED
ES
AIV,
VBV,
MTC,
CC,
CC
NAI
FRV
115V AC EXCITER PWR
28V DC EEC PWR
TLA
A/C DISCRETE INPUTS
EEC B
Ignition Exciter 2
Acclrm. Bearing 1

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VSV: Variable Stator Vane

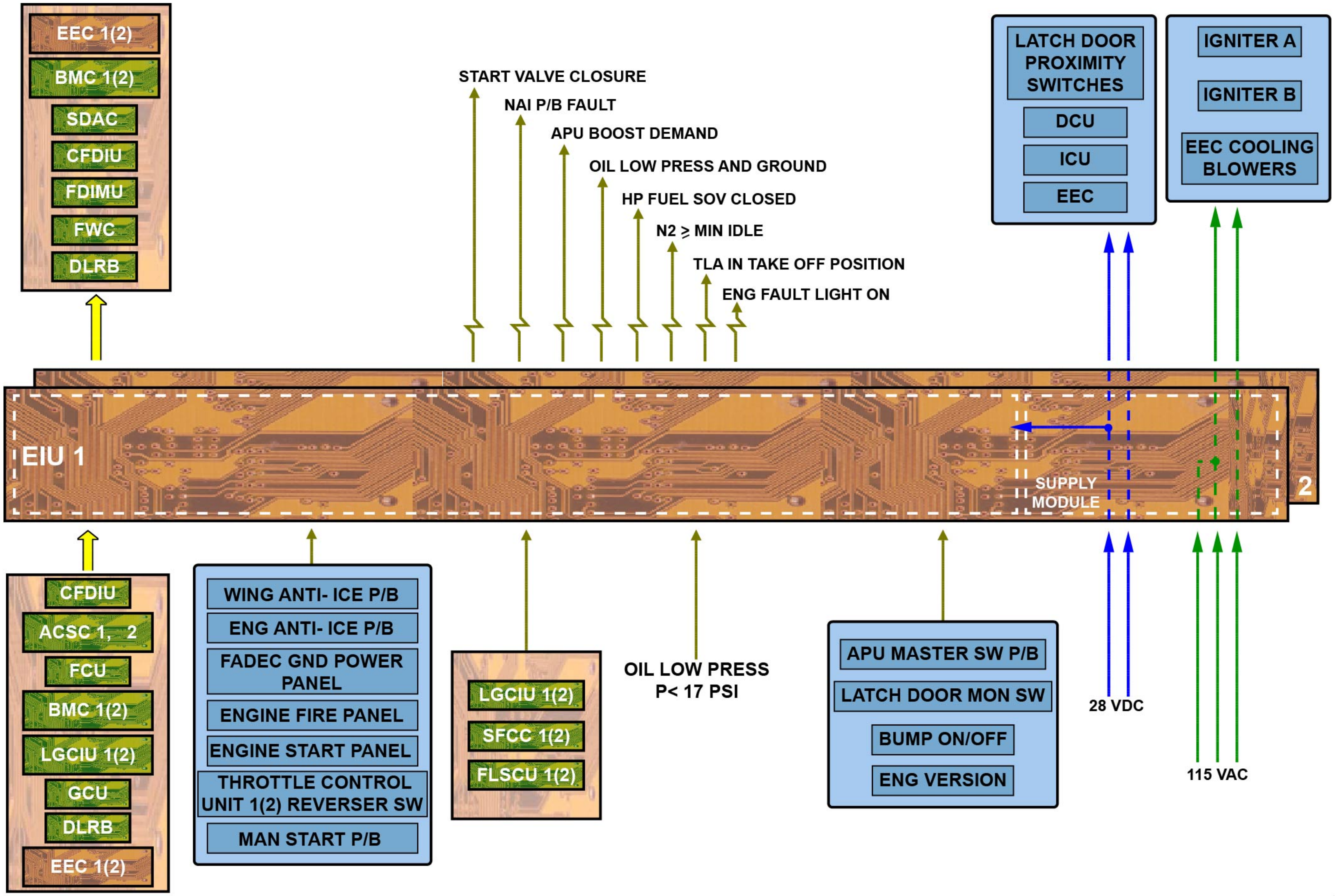
PSS

FADEC INTERFACES

AIRCRAFT / FADEC INTERFACES

EIU

The FADEC interfaces with its Engine Interface Unit (EIU) for power supply and Aircraft systems commands and feedback.
The FADEC for management needs direct connection with Aircraft Computers (Flight Management and Guidance Computer (FMGC), Air Data and Inertial Reference System (ADIRS), Flight Warning Computer (FWC)...) and receives discrete inputs as the Throttle Lever Angle (TLA), Master Switch OFF position for shut-down and reset.


EEC 1(2)
BMC 1(2)
SDAC
CFDIU
FDIMU
FWC
DLRB
START VALVE CLOSURE
NAI P/B FAULT
APU BOOST DEMAND
OIL LOW PRESS AND GROUND
HP FUEL SOV CLOSED
N2 ≥ MIN IDLE
TLA IN TAKE OFF POSITION
ENG FAULT LIGHT ON
LATCH DOOR PROXIMITY SWITCHES
DCU
ICU
EEC
IGNITER A
IGNITER B
EEC COOLING BLOWERS
EIU 1
SUPPLY MODULE
2
CFDIU
ACSC 1, 2
FCU
BMC 1(2)
LGCIU 1(2)
GCU
DLRB
EEC 1(2)
WING ANTI- ICE P/B
ENG ANTI- ICE P/B
FADEC GND POWER PANEL
ENGINE FIRE PANEL
ENGINE START PANEL
THROTTLE CONTROL UNIT 1(2) REVERSER SW
MAN START P/B
LGCIU 1(2)
SFCC 1(2)
FLSCU 1(2)
OIL LOW PRESS P< 17 PSI
APU MASTER SW P/B
LATCH DOOR MON SW
BUMP ON/OFF
ENG VERSION
28 VDC
115 VAC

AIRCRAFT / FADEC INTERFACES - EIU

FADEC INTERFACES

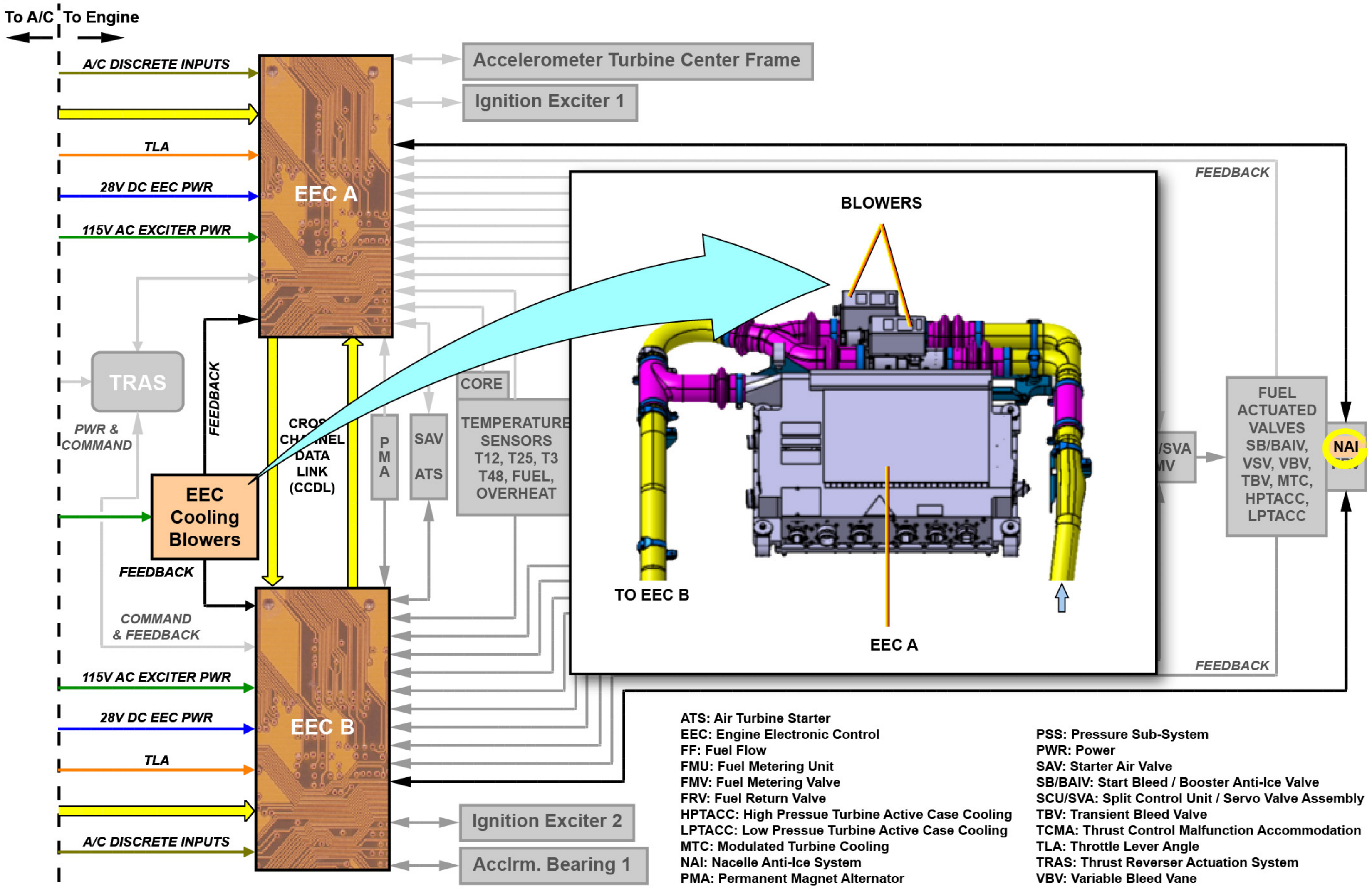
AIRCRAFT / FADEC INTERFACES (continued)

BLOWERS

Both EECs are ventilated by 2 blowers when the EIU contacts an external relay on demand of the EEC.

NACELLE ANTI-ICE SYSTEM

The EECs control and monitor the Nacelle Anti-Ice (NAI) system with:
- 2 Anti-Ice Pressure Regulating Shutoff Valves (PRSOVs),
- 2 pressure sensors,
- a dual temperature sensor.


To A/C
To Engine
A/C DISCRETE INPUTS
TLA
28V DC EEC PWR
115V AC EXCITER PWR
EEC A
Accelerometer Turbine Center Frame
Ignition Exciter 1
FEEDBACK
TRAS
PWR & COMMAND
FEEDBACK
EEC Cooling Blowers
FEEDBACK
COMMAND & FEEDBACK
CROS CH NEL DATA LINK (CCDL)
P M A
SAV
ATS
CORE
TEMPERATURE SENSORS T12, T25, T3 T48, FUEL, OVERHEAT
BLOWERS
TO EEC B
EEC A
/SVA
MV
FUEL ACTUATED VALVES SB/BAIV, VSV, VBV, TBV, MTC, HPTACC, LPTACC
NAI
FEEDBACK
EEC B
115V AC EXCITER PWR
28V DC EEC PWR
TLA
A/C DISCRETE INPUTS
Ignition Exciter 2
Acclrm. Bearing 1

ATS: Air Turbine Starter
EEC: Engine Electronic Control
FF: Fuel Flow
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
FRV: Fuel Return Valve
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LPTACC: Low Pressue Turbine Active Case Cooling
MTC: Modulated Turbine Cooling
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PMV: Pilot Metering Valve
PSS: Pressure Sub-System
PWR: Power
SAV: Starter Air Valve
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SCU/SVA: Split Control Unit / Servo Valve Assembly
TBV: Transient Bleed Valve
TCMA: Thrust Control Malfunction Accommodation
TLA: Throttle Lever Angle
TRAS: Thrust Reverser Actuation System
VBV: Variable Bleed Vane
VSV: Variable Stator Vane

AIRCRAFT / FADEC INTERFACES - BLOWERS & NACELLE ANTI-ICE SYSTEM

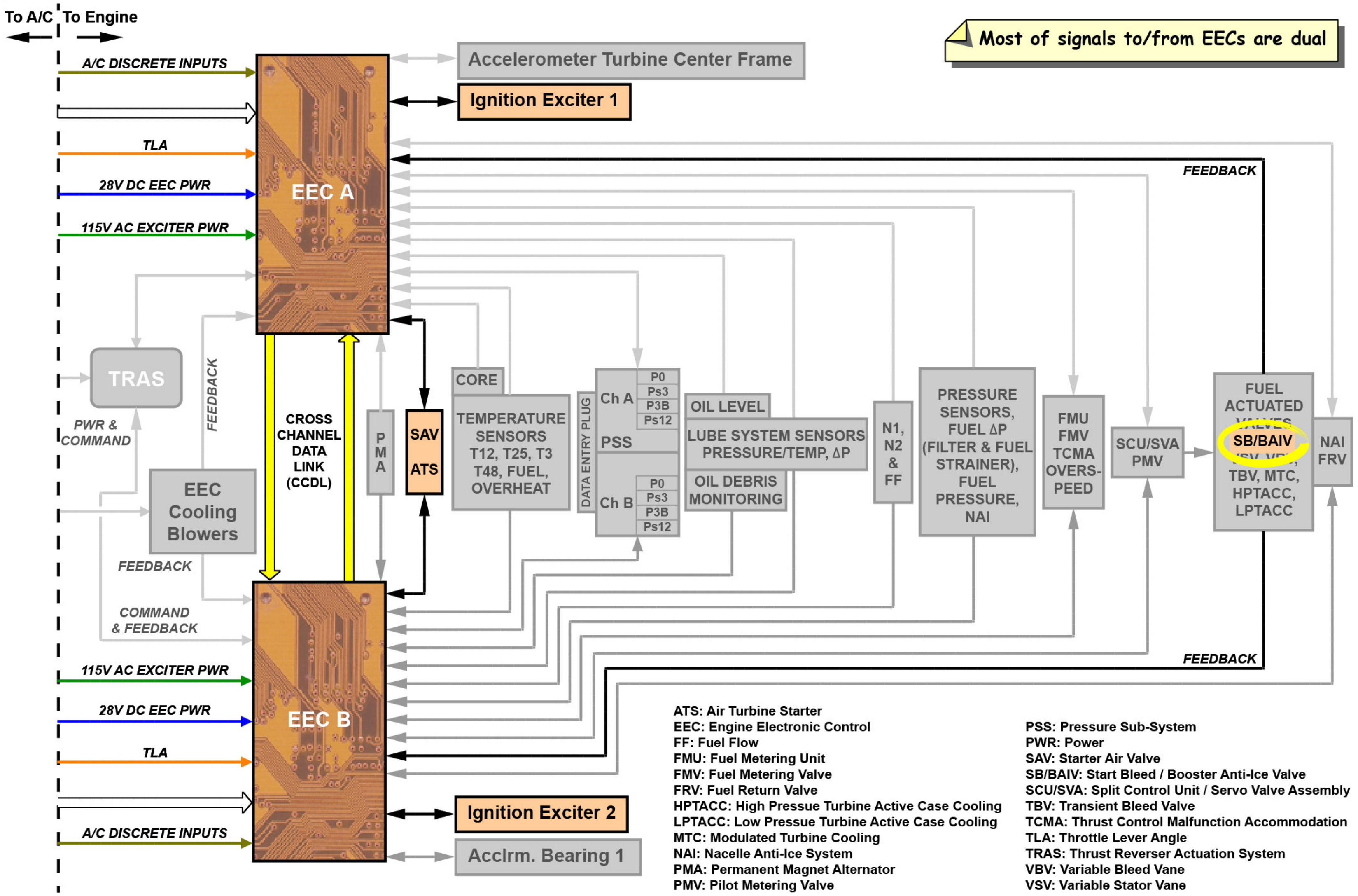
FADEC INTERFACES

ENGINE INTERFACES

An EEC is the main controller and monitoring device over the engine subsystems.
Unless specified differently, signals are dual (from/to both EEC channels).
The EECs adjust the fuel and air systems to produce the thrust requested and engine airflow needed for cooling.
Each EEC uses inputs provided by the PSS, engine sensors, probes, and information from the aircraft computers, switches, and controls.
Each EEC processes this information and performs calculations of, and comparisons to, information stored in its memory.
The EEC "channel in control" adjusts the engine valves, actuators, and solenoids to provide the fuel and air needed to produce the thrust requested and engine airflow needed for cooling.

IGNITION AND STARTING SYSTEMS

For the Starting and Ignition sub-system, EECs control:
- 2 Ignition Exciters,
- Starter Air Valve (SAV),
- Air Turbine Starter (ATS),
- and a Start Bleed / Booster Anti-Ice Valve (SB/BAIV) to ease starting in icing condition.


To A/C
To Engine
Most of signals to/from EECs are dual
A/C DISCRETE INPUTS
TLA
28V DC EEC PWR
115V AC EXCITER PWR
EEC A
Accelerometer Turbine Center Frame
Ignition Exciter 1
FEEDBACK
TRAS
PWR & COMMAND
FEEDBACK
EEC Cooling Blowers
FEEDBACK
COMMAND & FEEDBACK
CROSS CHANNEL DATA LINK (CCDL)
P M A
SAV
ATS
CORE
TEMPERATURE SENSORS T12, T25, T3 T48, FUEL, OVERHEAT
DATA ENTRY PLUG
Ch A
P0
Ps3
P3B
Ps12
PSS
Ch B
P0
Ps3
P3B
Ps12
OIL LEVEL
LUBE SYSTEM SENSORS PRESSURE/TEMP, ΔP
OIL DEBRIS MONITORING
N1, N2 & FF
PRESSURE SENSORS, FUEL ΔP (FILTER & FUEL STRAINER), FUEL PRESSURE, NAI
FMU FMV TCMA OVERS-PEED
SCU/SVA PMV
FUEL ACTUATED VALVES
SB/BAIV
VSV, VBV,
TBV, MTC, HPTACC, LPTACC
NAI FRV
FEEDBACK
115V AC EXCITER PWR
28V DC EEC PWR
TLA
A/C DISCRETE INPUTS
EEC B
Ignition Exciter 2
Acclrm. Bearing 1

ATS: Air Turbine Starter
EEC: Engine Electronic Control
FF: Fuel Flow
FMU: Fuel Metering Unit
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FRV: Fuel Return Valve
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NAI: Nacelle Anti-Ice System
PMA: Permanent Magnet Alternator
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PSS: Pressure Sub-System
PWR: Power
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TBV: Transient Bleed Valve
TCMA: Thrust Control Malfunction Accommodation
TLA: Throttle Lever Angle
TRAS: Thrust Reverser Actuation System
VBV: Variable Bleed Vane
VSV: Variable Stator Vane

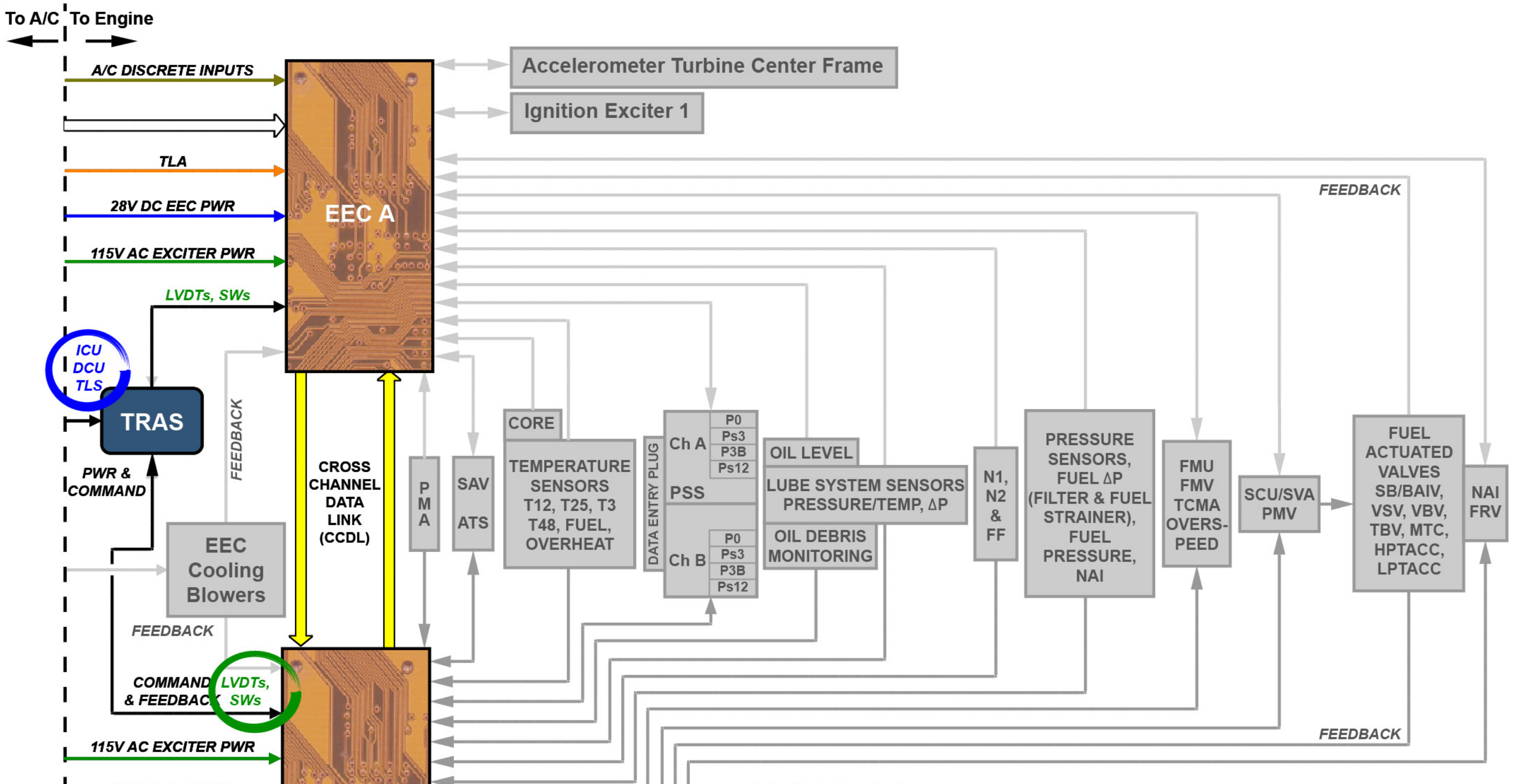
ENGINE INTERFACES - IGNITION AND STARTING SYSTEMS

FADEC INTERFACES

ENGINE INTERFACES (continued)

THRUST REVERSER SYSTEM

The Thrust Reverser sub-system is commanded by EECs via Isolation Control Unit (ICU) & Directional Control Unit (DCU) whose valve' solenoids are energized by EIU plus EEC, and Tertiary Lock System (TLS). Feedbacks position signals are given by Linear Variable Differential Transducers (LVDTs) & switches.


To A/C
To Engine
A/C DISCRETE INPUTS
TLA
28V DC EEC PWR
115V AC EXCITER PWR
LVDTs, SWs
EEC A
ICU
DCU
TLS
TRAS
PWR &
COMMAND
FEEDBACK
EEC
Cooling
Blowers
FEEDBACK
COMMAND
& FEEDBACK
LVDTs,
SWs
115V AC EXCITER PWR
28V DC EEC PWR
TLA
A/C DISCRETE INPUTS
EEC B
CROSS
CHANNEL
DATA
LINK
(CCDL)
P
M
A
SAV
ATS
Accelerometer Turbine Center Frame
Ignition Exciter 1
FEEDBACK
CORE
TEMPERATURE
SENSORS
T12, T25, T3
T48, FUEL,
OVERHEAT
DATA ENTRY PLUG
Ch A
P0
Ps3
P3B
Ps12
PSS
Ch B
P0
Ps3
P3B
Ps12
OIL LEVEL
LUBE SYSTEM SENSORS
PRESSURE/TEMP, ΔP
OIL DEBRIS
MONITORING
N1,
N2
&
FF
PRESSURE
SENSORS,
FUEL ΔP
(FILTER & FUEL
STRAINER),
FUEL
PRESSURE,
NAI
FMU
FMV
TCMA
OVERS-
PEED
SCU/SVA
PMV
FUEL
ACTUATED
VALVES
SB/BAIV,
VSV, VBV,
TBV, MTC,
HPTACC,
LPTACC
NAI
FRV
FEEDBACK
Ignition Exciter 2
Acclrm. Bearing 1

ATS: Air Turbine Starter
EEC: Engine Electronic Control
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TBV: Transient Bleed Valve
TCMA: Thrust Control Malfunction Accommodation
TLA: Throttle Lever Angle
TRAS: Thrust Reverser Actuation System
VBV: Variable Bleed Vane
VSV: Variable Stator Vane

ENGINE INTERFACES - THRUST REVERSER SYSTEM

FADEC INTERFACES

ENGINE INTERFACES (continued)

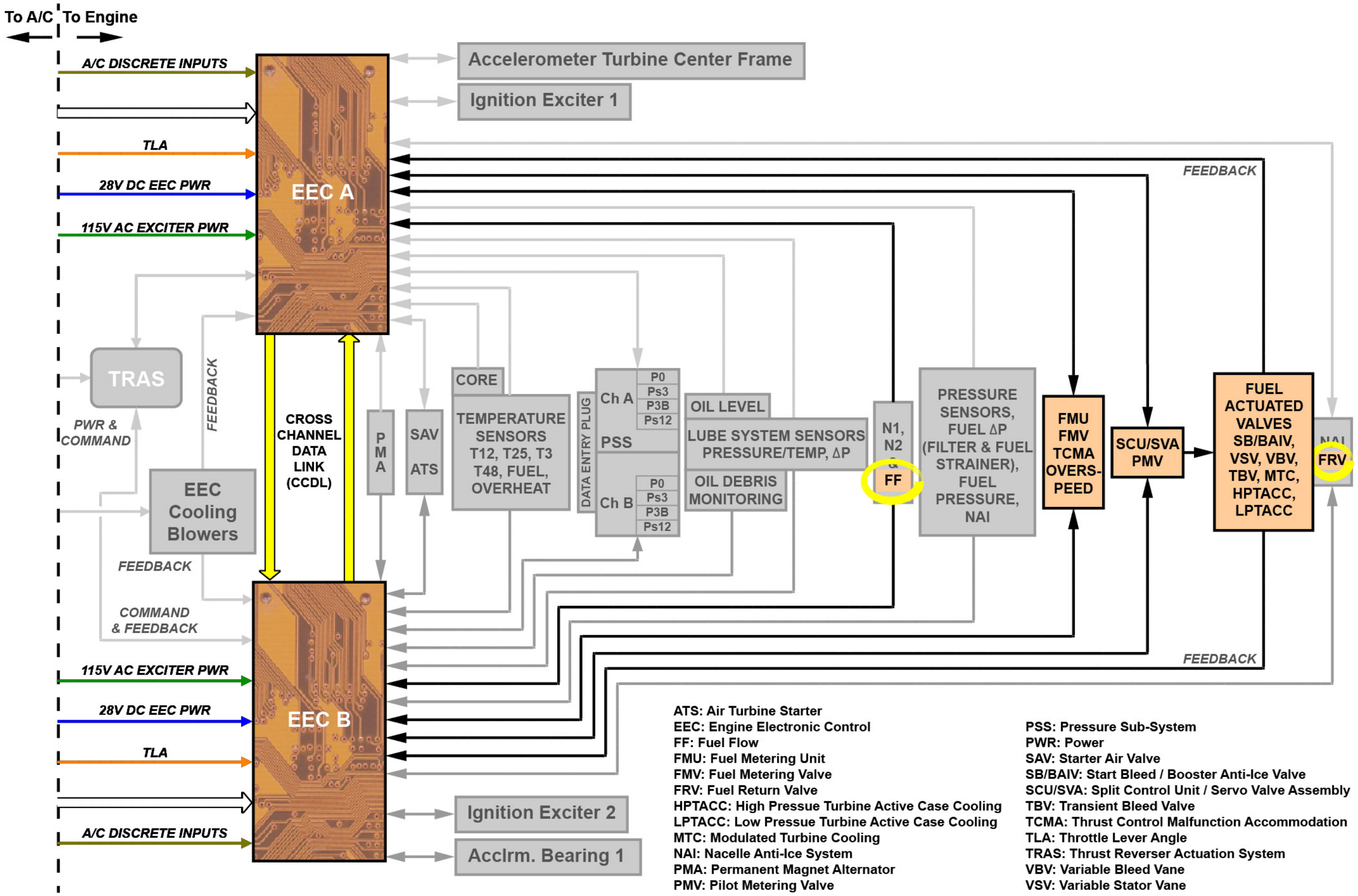
FUEL & AIR SYSTEM

For the Fuel sub-system, the EECs Control and monitor the:
- Fuel Metering Unit (FMU),
- Fuel Metering Valve (FMV),
- High Pressure Shut-Off Valve (HPSOV),
- Overspeed,
- Thrust Control Malfunction Accommodation (TCMA): The EEC reads a hardwired shutoff (ground phase) permissive analog discrete sent by the Spoiler and Elevator Computer (SEC) to enable the Thrust Control Malfunction (TCM) Fuel Shutoff functionality.
- Split Control Unit / Servo Valve Assembly (SCU / SVA): Converts the EEC electrical signals to hydraulic flows and provides the Pilot Metering Valve (PMV) feedback to both EECs.
- Fuel Return Valve (FRV) (different levels of re-circulated fuel flow).

Most of Air valves are fuel actuated and EEC controlled.

For compressor airflow:
- Variable Stator Vanes (VSVs),
- Variable Bleed Valves (VBVs),
- SB/BAIV,
- Transient Bleed Valve (TBV).

For cooling:
- Modulated Turbine Cooling (MTC),
- HP & LP Turbine Active Case Cooling (HP & LPTACC).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To Engine
A/C DISCRETE INPUTS
TLA
28V DC EEC PWR
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EEC A
Accelerometer Turbine Center Frame
Ignition Exciter 1
FEEDBACK
TRAS
PWR & COMMAND
FEEDBACK
EEC Cooling Blowers
FEEDBACK
COMMAND & FEEDBACK
CROSS CHANNEL DATA LINK (CCDL)
P M A
SAV
ATS
CORE
TEMPERATURE SENSORS T12, T25, T3 T48, FUEL, OVERHEAT
DATA ENTRY PLUG
Ch A
P0
Ps3
P3B
Ps12
PSS
Ch B
P0
Ps3
P3B
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OIL LEVEL
LUBE SYSTEM SENSORS PRESSURE/TEMP, ΔP
OIL DEBRIS MONITORING
N1, N2 & FF
PRESSURE SENSORS, FUEL ΔP (FILTER & FUEL STRAINER), FUEL PRESSURE, NAI
FMU FMV TCMA OVERSPEED
SCU/SVA PMV
FUEL ACTUATED VALVES SB/BAIV, VSV, VBV, TBV, MTC, HPTACC, LPTACC
NAI
FRV
FEEDBACK
115V AC EXCITER PWR
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TLA
A/C DISCRETE INPUTS
EEC B
Ignition Exciter 2
Acclrm. Bearing 1

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ENGINE INTERFACES - FUEL & AIR SYSTEM

FADEC INTERFACES

ENGINE INTERFACES (continued)

SENSORS

Most engine parameters required for control logic use dual redundant sensors.

Temperature sensors:

- T12 inlet,
- T25,
- T3 High Pressuser Compressor (HPC) outlet,
- T48 = Exhaust Gas Temperature (EGT) (2 groups of 4 = 8),
- Fuel,
- Overheat (NAI/starter air fan case monitoring).

NOTE: Note: The Core Temp sensor signal is going to EEC A only.

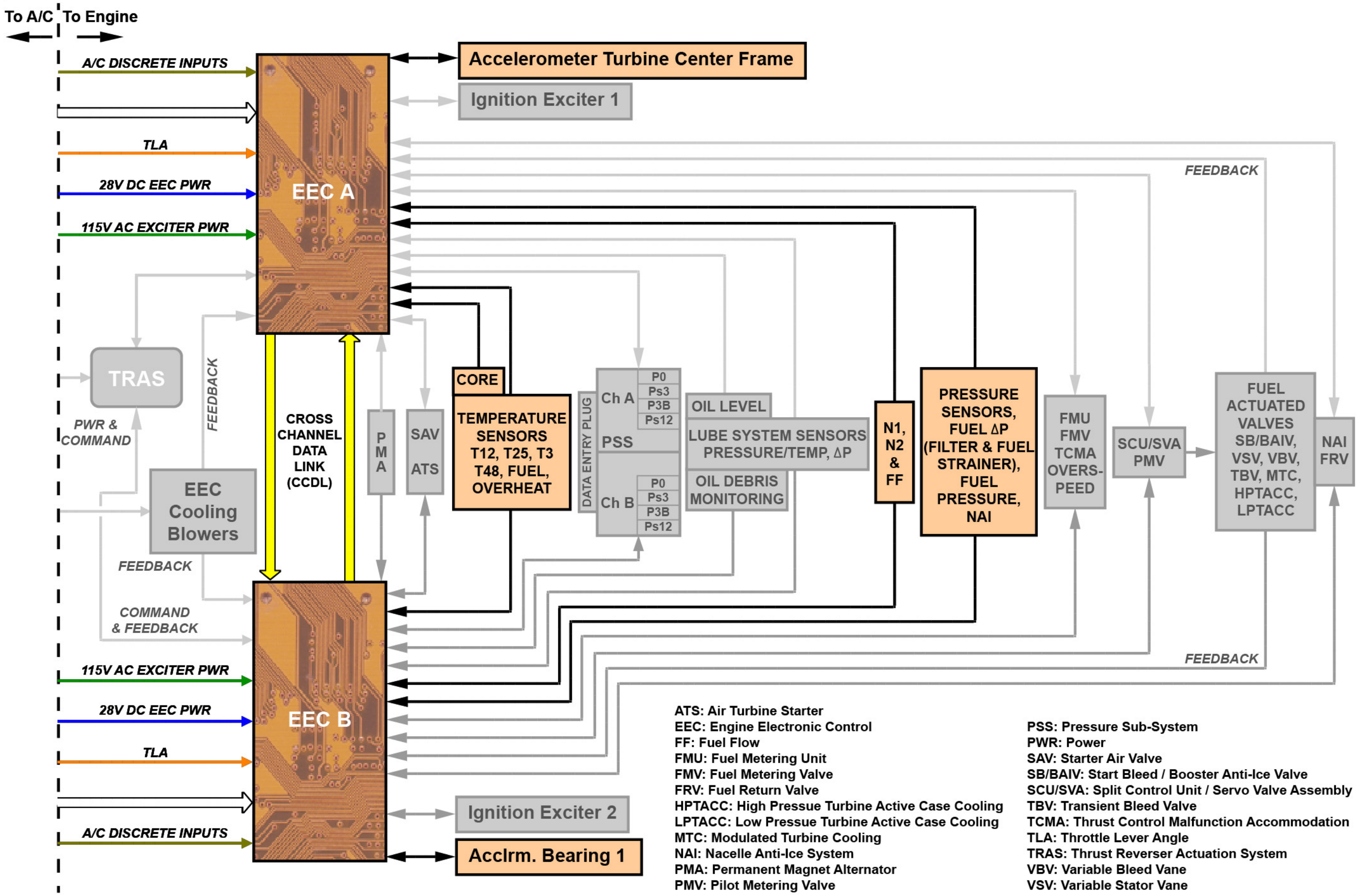
Speed sensors:

- N1,
- N2.

Fuel Flow (FF)
Pressure Sensors (direct signals not via the PSS):

- Fuel,
- Fuel Differential Pressure Sensors,
- NAI

2 vibration sensors:
- Turbine Center Frame (TCF) Sensor connected to EEC A,
- Forward Vibration Sensor at Bearing 1 connected to EEC B.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To Engine
A/C DISCRETE INPUTS
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28V DC EEC PWR
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Ignition Exciter 1
FEEDBACK
TRAS
PWR & COMMAND
FEEDBACK
EEC Cooling Blowers
FEEDBACK
COMMAND & FEEDBACK
CROSS CHANNEL DATA LINK (CCDL)
P M A
SAV
ATS
CORE
TEMPERATURE SENSORS T12, T25, T3 T48, FUEL, OVERHEAT
DATA ENTRY PLUG
Ch A
P0
Ps3
P3B
Ps12
PSS
Ch B
P0
Ps3
P3B
Ps12
OIL LEVEL
LUBE SYSTEM SENSORS PRESSURE/TEMP, ΔP
OIL DEBRIS MONITORING
N1, N2 & FF
PRESSURE SENSORS, FUEL ΔP (FILTER & FUEL STRAINER), FUEL PRESSURE, NAI
FMU FMV TCMA OVERS-PEED
SCU/SVA PMV
FUEL ACTUATED VALVES SB/BAIV, VSV, VBV, TBV, MTC, HPTACC, LPTACC
NAI FRV
FEEDBACK
115V AC EXCITER PWR
28V DC EEC PWR
TLA
A/C DISCRETE INPUTS
EEC B
Ignition Exciter 2
Acclrm. Bearing 1

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ENGINE INTERFACES - SENSORS

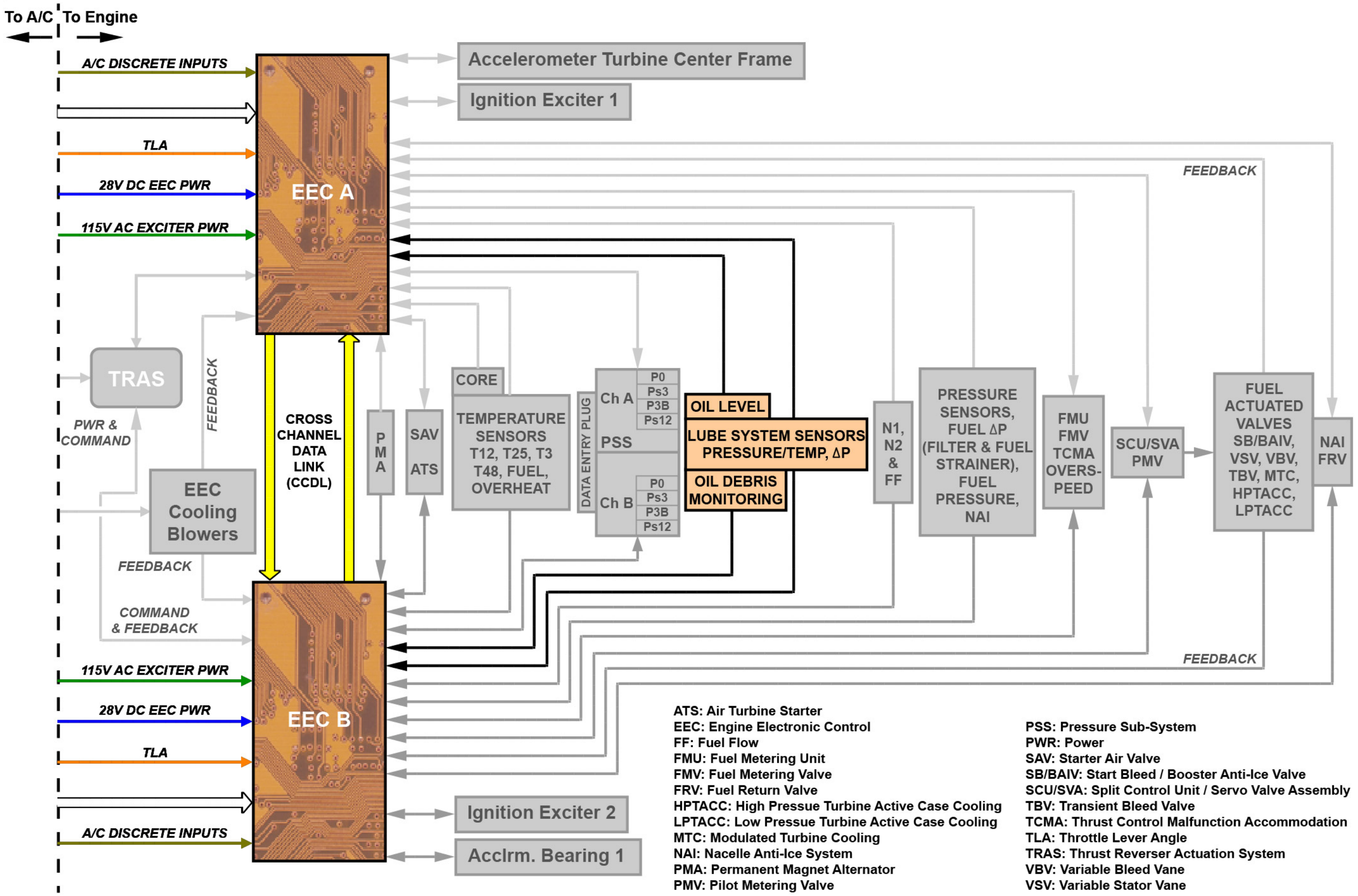
FADEC INTERFACES

ENGINE INTERFACES (continued)

OIL SYSTEM

The Oil sub-system is monitored by the EEC A & B in pressure, temperature and clogging (Oil Filter Differential Pressure sensor).

NOTE: Note: Low Oil Pressure (LOP) switch feedback is sent to the EIU.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To Engine
A/C DISCRETE INPUTS
TLA
28V DC EEC PWR
115V AC EXCITER PWR
EEC A
Accelerometer Turbine Center Frame
Ignition Exciter 1
FEEDBACK
TRAS
PWR & COMMAND
FEEDBACK
EEC Cooling Blowers
FEEDBACK
COMMAND & FEEDBACK
CROSS CHANNEL DATA LINK (CCDL)
P M A
SAV
ATS
CORE
TEMPERATURE SENSORS T12, T25, T3 T48, FUEL, OVERHEAT
DATA ENTRY PLUG
Ch A
P0
Ps3
P3B
Ps12
PSS
Ch B
P0
Ps3
P3B
Ps12
OIL LEVEL
LUBE SYSTEM SENSORS PRESSURE/TEMP, ΔP
OIL DEBRIS MONITORING
N1, N2 & FF
PRESSURE SENSORS, FUEL ΔP (FILTER & FUEL STRAINER), FUEL PRESSURE, NAI
FMU FMV TCMA OVERSPEED
SCU/SVA PMV
FUEL ACTUATED VALVES SB/BAIV, VSV, VBV, TBV, MTC, HPTACC, LPTACC
NAI FRV
FEEDBACK
115V AC EXCITER PWR
28V DC EEC PWR
TLA
A/C DISCRETE INPUTS
EEC B
Ignition Exciter 2
Acclrm. Bearing 1

ATS: Air Turbine Starter
EEC: Engine Electronic Control
FF: Fuel Flow
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
FRV: Fuel Return Valve
HPTACC: High Pressue Turbine Active Case Cooling
LPTACC: Low Pressure Turbine Active Case Cooling
MTC: Modulated Turbine Cooling
NAI: Nacelle Anti-Ice System
PMA: Permanent Magnet Alternator
PMV: Pilot Metering Valve
PSS: Pressure Sub-System
PWR: Power
SAV: Starter Air Valve
SB/BAIV: Start Bleed / Booster Anti-Ice Valve
SCU/SVA: Split Control Unit / Servo Valve Assembly
TBV: Transient Bleed Valve
TCMA: Thrust Control Malfunction Accommodation
TLA: Throttle Lever Angle
TRAS: Thrust Reverser Actuation System
VBV: Variable Bleed Vane
VSV: Variable Stator Vane

ENGINE INTERFACES - OIL SYSTEM

FADEC ELECTRICAL POWER SUPPLY CONTROL

EEC

The Full Authority Digital Engine Control (FADEC) system is designed with an electrically dual redundant architecture.
Each Electronic Engine Control (EEC) unit is electrically supplied by the A/C electrical network when high pressure rotor speed (N2) is below 8% (or when the dedicated Permanent Magnet Alternator (PMA) has failed) and then, by its dedicated PMA when N2 is above 8%.

AIRCRAFT POWER

The FADEC system is supplied by the A/C electrical power network through the Engine Interface Unit (EIU) when N2 is below 8%.
EEC Channel A is supplied by 28V DC essential bus, while EEC Channel B is supplied by 28V DC normal bus.
The aircraft 28V DC permits the EEC to:
- automatic ground check of the FADEC system when the engine is not running, that is to say FADEC GrouND PoWeR ON for interactive tests and data loading,
- control starting: MASTER lever ON or mode selector on IGNition or CRANK, Starter Air Valve (SAV),
- control reverser system.

NOTE: The EIU takes its power from the same bus bar as the EEC.

PMA SUPPLY

The PMA is located on the AFT side of the Accessory Gearbox (AGB).
As soon as the engine is running above 8% of N2, the PMA directly supplies each EEC unit with three-phase AC power. Two transformer rectifiers provide 28V DC power supply to channels A and B.
Switching between the A/C 28V DC supply and the dedicated alternator power supplies is done automatically by the EEC.

NOTE: Each PSS channel is supplied via its corresponding EEC.

AUTO DEPOWERING

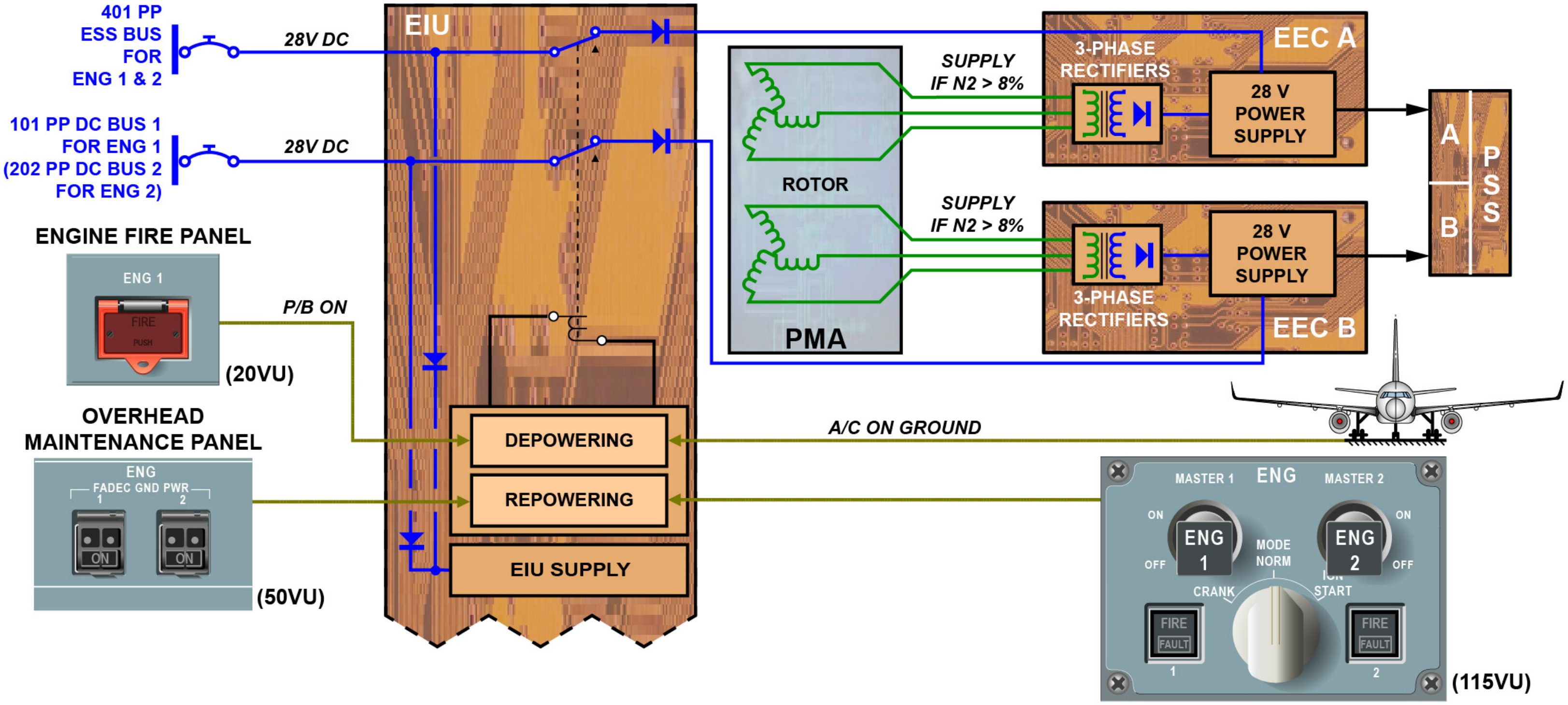
The EECs automatic depowering occur on the ground through the EIU 5 min after A/C power-up if no action done on engine system.
After engine shutdown, the EECs remain powered during 5 minutes to allow engine parameters monitoring.
Power is not cut-off if Centralized Fault Display System (CFDS) EEC menus are active or Data Loading going on (software upload/memory dump).

NOTE: An action on the ENGine FIRE P/B provides EEC power cut-off from the A/C network.

MANUAL REPOWERING

For maintenance purposes and Engine tests (CFDS), the ENGine FADEC GrouND PoWeR panel permits FADEC power supply to be restored on the ground while engines are shut down. When the corresponding ENGine FADEC GrouND PoWeR P/B is pressed ON the EEC recovers its power supply.

NOTE: The FADEC is also repowered as soon as the engine start selector is in IGNition/START or CRANK position, or the MASTER lever is selected ON.


401 PP
ESS BUS
FOR
ENG 1 & 2
28V DC
101 PP DC BUS 1
FOR ENG 1
(202 PP DC BUS 2
FOR ENG 2)
28V DC
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
P/B ON
(20VU)
OVERHEAD
MAINTENANCE PANEL
ENG
FADEC GND PWR
1
2
ON
ON
(50VU)
EIU
DEPOWERING
REPOWERING
EIU SUPPLY
ROTOR
PMA
SUPPLY
IF N2 > 8%
SUPPLY
IF N2 > 8%
3-PHASE
RECTIFIERS
EEC A
28 V
POWER
SUPPLY
3-PHASE
RECTIFIERS
EEC B
28 V
POWER
SUPPLY
A
B
P
S
S
A/C ON GROUND
MASTER 1
ENG
MASTER 2
ON
OFF
ENG
1
ENG
2
ON
OFF
MODE
NORM
CRANK
IGN
START
FIRE
FAULT
1
FIRE
FAULT
2
(115VU)

EEC: Electronic Engine Control
EIU: Engine Interface Unit
PMA: Permanent Magnet Alternator
PSS: Pressure Sub System

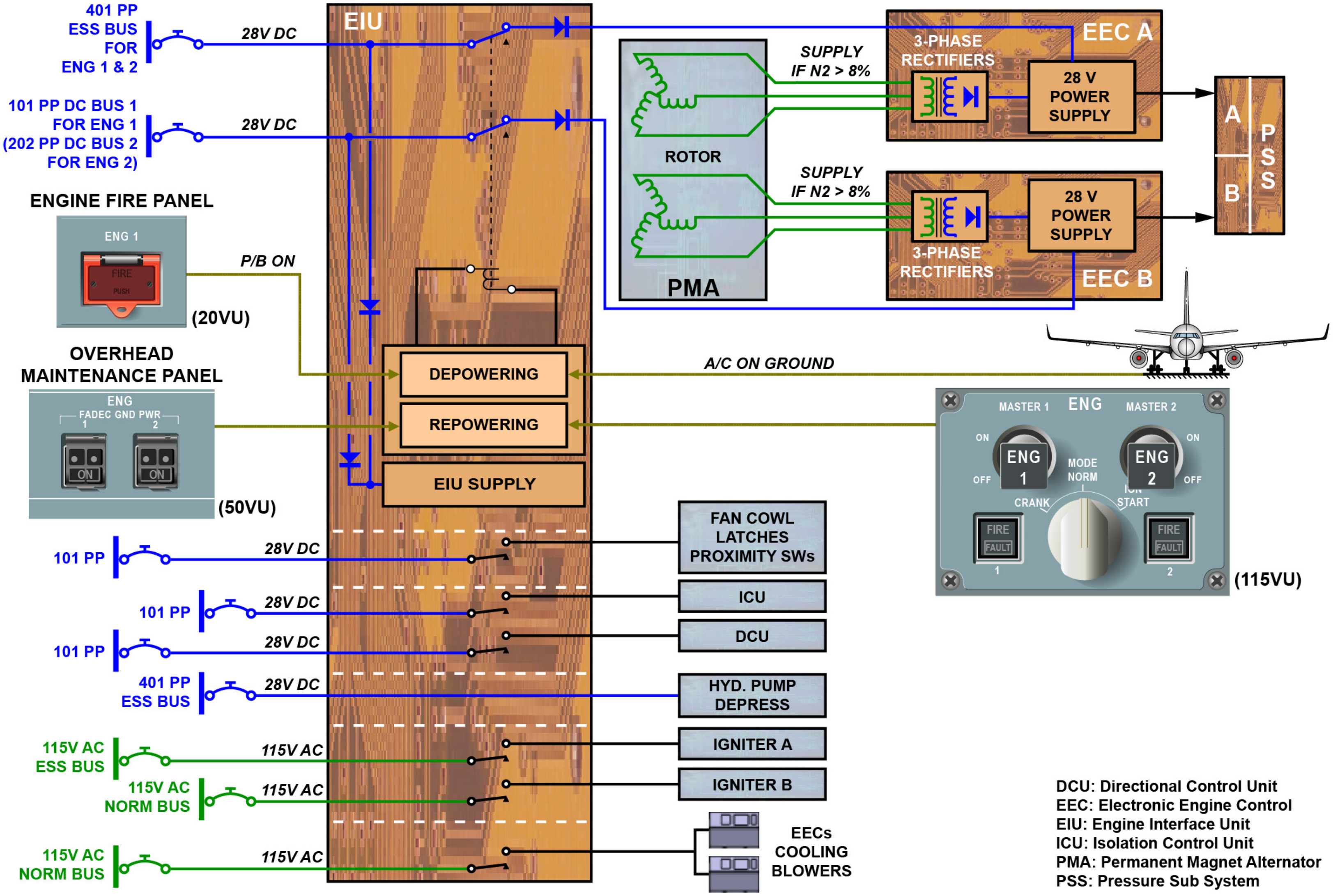
EEC - AIRCRAFT POWER ... MANUAL REPOWERING

FADEC ELECTRICAL POWER SUPPLY CONTROL

SUBSYSTEMS POWER SUPPLY

The EIU manages the power supplies for the following sub-systems.
The Fan cowl door proximity switches are supplied in 28V DC.
The EIU controls the 28V DC power to the Reverser system units for Isolation and Directional control.
The Power Control System (PCS) needs to be able to command the hydraulic pump depressurization in certain environmental conditions when an in flight engine flame out has occurred to ease the restart. The hydraulic pump depressurization is requested by the EEC and the Hydraulic Pump Depress solenoid is supplied by the EIU.
Each starting igniter is independently supplied with 115V AC: Igniter A from the Essential bus and Igniter B normal bus.
The EIU is in charge of controlling the external relay, providing 115V AC three phases, for the 2 FADEC Blowers Power Supply thanks to a discrete output.

NOTE: Note: The FADEC Blower will be supplied by an external relay in the avionics bay which will be commanded by a discrete signal sent from the EIU.


401 PP
ESS BUS
FOR
ENG 1 & 2
28V DC
101 PP DC BUS 1
FOR ENG 1
(202 PP DC BUS 2
FOR ENG 2)
28V DC
EIU
ENGINE FIRE PANEL
ENG 1
FIRE
PUSH
P/B ON
(20VU)
OVERHEAD
MAINTENANCE PANEL
ENG
FADEC GND PWR
1
2
ON
ON
(50VU)
DEPOWERING
REPOWERING
EIU SUPPLY
ROTOR
PMA
SUPPLY
IF N2 > 8%
SUPPLY
IF N2 > 8%
3-PHASE
RECTIFIERS
EEC A
28 V
POWER
SUPPLY
28 V
POWER
SUPPLY
3-PHASE
RECTIFIERS
EEC B
A
B
P
S
S
A/C ON GROUND
MASTER 1
ENG
MASTER 2
ON
OFF
ENG
1
MODE
NORM
ENG
2
ON
OFF
CRANK
IGN
START
FIRE
FAULT
1
FIRE
FAULT
2
(115VU)
101 PP
28V DC
FAN COWL
LATCHES
PROXIMITY SWs
101 PP
28V DC
ICU
101 PP
28V DC
DCU
401 PP
ESS BUS
28V DC
HYD. PUMP
DEPRESS
115V AC
ESS BUS
115V AC
IGNITER A
115V AC
NORM BUS
115V AC
IGNITER B
115V AC
NORM BUS
115V AC
EECs
COOLING
BLOWERS

DCU: Directional Control Unit
EEC: Electronic Engine Control
EIU: Engine Interface Unit
ICU: Isolation Control Unit
PMA: Permanent Magnet Alternator
PSS: Pressure Sub System

SUBSYSTEMS POWER SUPPLY

IGNITION AND STARTING SYSTEM PRESENTATION

GENERAL

The Ignition system provides the electrical spark needed to start or continue engine combustion. The ignition system consists of two independent circuits per engine. Each circuit includes one ignition exciter (housed within the exciter shroud box), one coaxial shield ignition lead and one igniter plug.

The Starting system drives the engine High Pressure (HP) rotor at a speed high enough for a ground or in flight start to be initiated. The start system is made up of the Starter Air Valve (SAV) and the Air Turbine Starter (ATS). Air bleed for engine start is supplied by the aircraft pneumatic system (Auxiliary Power Unit (APU) bleed, external pneumatic cart, opposite engine bleed).

CONTROL AND INDICATING

The Electronic Engine Control (EEC) controls the ignition during automatic start and manual start. 115 V AC from aircraft electrical system is supplied to the ignition exciter(s) which provides the necessary voltage to the igniter plug(s) to generate the sparks for combustion.

The EEC controls the starting through the SAV during automatic start and manual start.

The SAV and the ignition system operation is displayed on the ENGINE ECAM page.

AUTOMATIC START

During an automatic start on ground, when the rotary start mode selector is set to IGN/START and the ENGine MASTER lever is set to ON, the EEC opens the SAV to motor the engine for start. One ignition exciter is then energized when the HP rotor speed is nominal. The EEC provides full protection during the start sequence. When the automatic start is completed, the EEC closes the SAV and cuts off the ignition. In case of an incident during the ground automatic start, the EEC can manage up to two restart attempts or abort the start procedure.

MANUAL START

During a manual start, provided the rotary start mode selector is set to IGN/START, the SAV opens when the engine MANual START P/B is pressed in, then both ignition exciters are energized when the ENGine MASTER lever is set to the ON position. Only limited protections are accommodated by the EEC for ground start.

CRANKING

Engine motoring can be performed for dry cranking or wet cranking sequences, provided the rotary start mode selector is set to CRANK and the engine MANual START P/B is pressed in.

NOTE: during cranking ignition is inhibited.

CONTINUOUS IGNITION

With engine running, continuous ignition can be selected via the EEC either manually using the rotary start mode selector or automatically by the Full Authority Digital Engine Control (FADEC) during specific conditions.

NOTE: during continuous ignition, both igniters are supplied.

PRE-START MOTORING

Prior any ground starts or ground cranking procedures; the Pre-Start Motoring is active to cool down the engine as long as the bowed rotor conditions are detected.

NOTE: Pre-Start Motoring will limit N2 to 30% and inhibits ignition and fuel flow.

Bowed rotor condition depends on N2 vibration and T3 residual value.

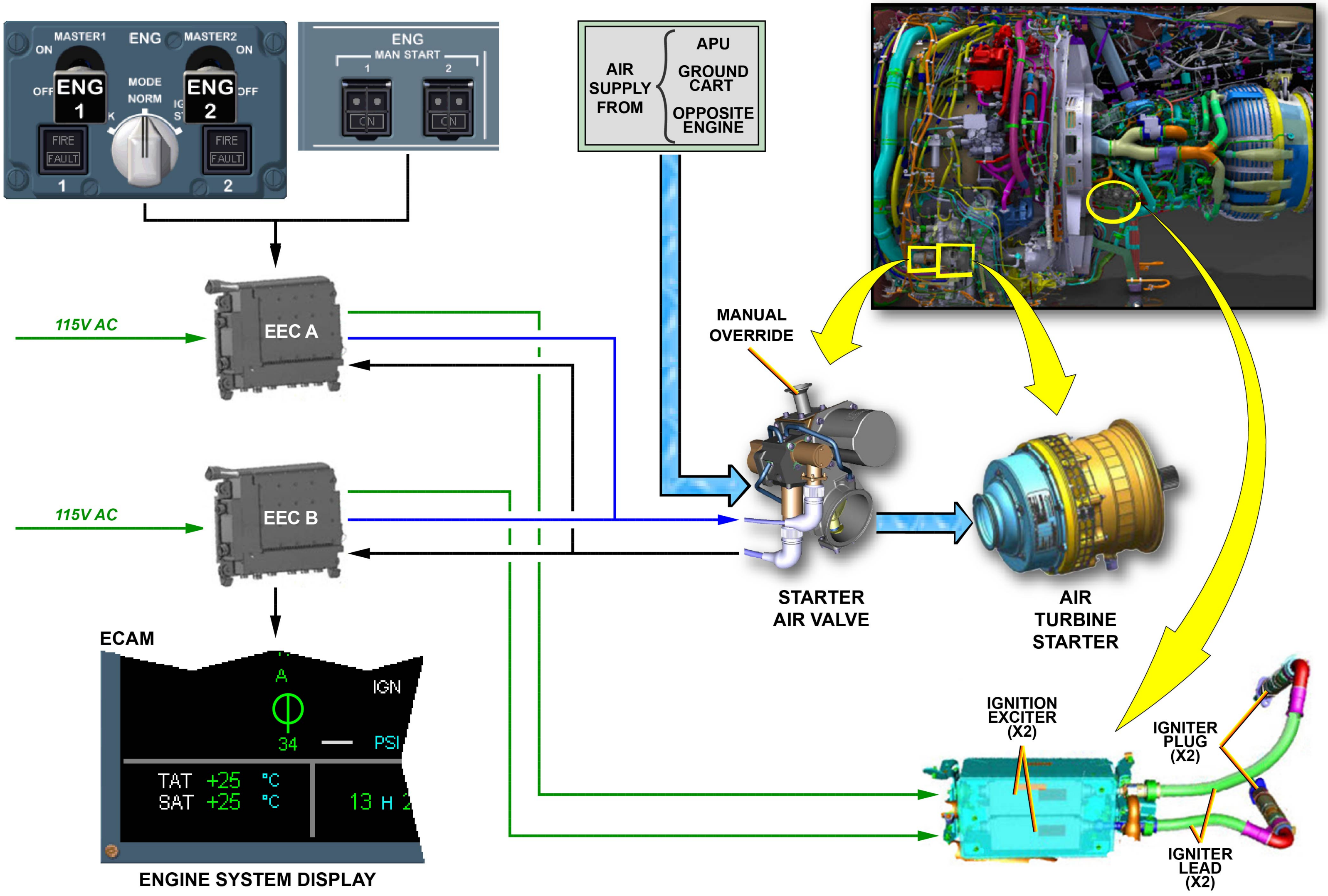
SAFETY PRECAUTIONS

Safety precautions have to be taken prior to working in this area.

WARNING: EACH IGNITION EXCITER PROVIDES HIGH ENERGY PULSES THROUGH THE IGNITION LEAD TO ITS OWN IGNITER PLUG.

MAINTENANCE PRACTICES

To increase A/C dispatch reliability, the SAV is equipped with a manual override for ground start assistance. For this manual operation, the mechanic has to be aware of the engine safety zones and procedures.


MASTER1
ENG
MASTER2
ON
ON
OFF
ENG 1
MODE
NORM
ENG 2
OFF
FIRE
FAULT
FIRE
FAULT
1
2
ENG
MAN START
1
2
ON
ON
AIR SUPPLY FROM
APU
GROUND CART
OPPOSITE ENGINE
115V AC
EEC A
115V AC
EEC B
MANUAL OVERRIDE
STARTER AIR VALVE
AIR TURBINE STARTER
ECAM
A
IGN
34
PSI
TAT +25 °C
SAT +25 °C
13 H
ENGINE SYSTEM DISPLAY
IGNITION EXCITER (X2)
IGNITER PLUG (X2)
IGNITER LEAD (X2)

GENERAL ... MAINTENANCE PRACTICES

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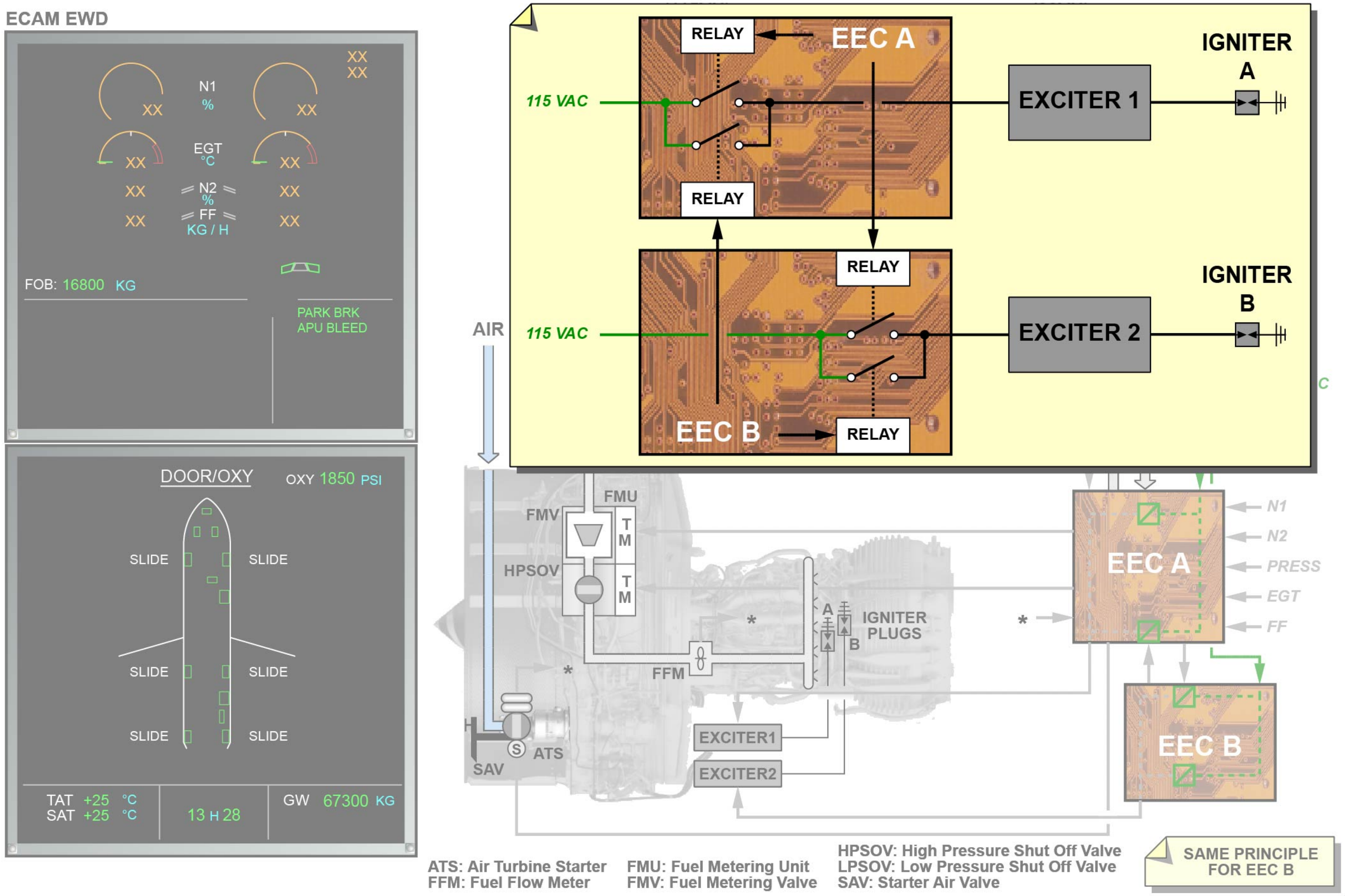
IGNITION AND STARTING SYSTEM D/O (ME)

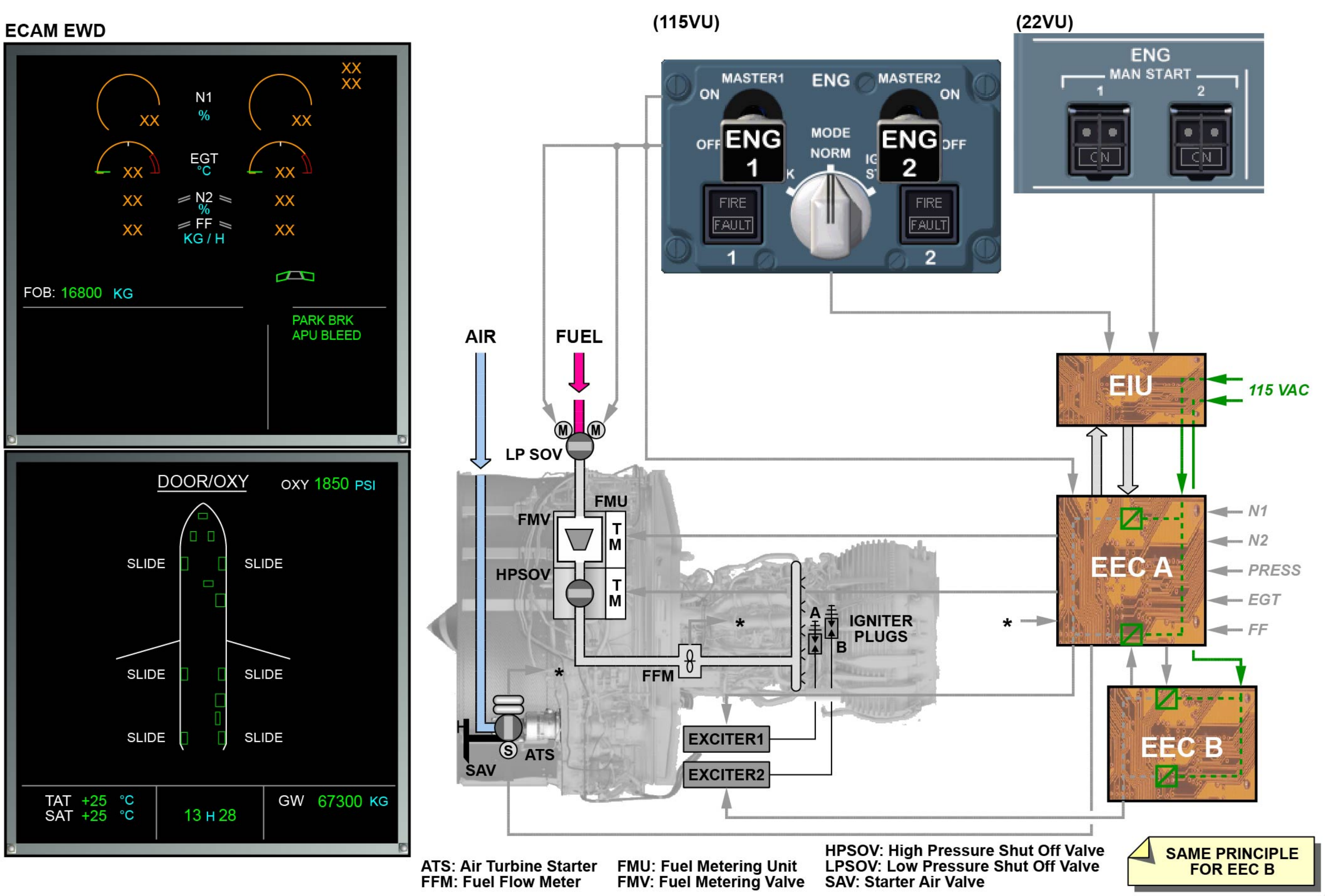
GENERAL

The FADEC controls and monitors the Starting and Ignition systems for engine starting, cranking, and ignition selection, on ground and in flight.
For engine starting, two modes are available; automatic or manual.
Both modes can be used on ground or in flight but the in-flight sequences are less protective to enhance the restart capability.
For engine cranking, two sequences can be manually selected: dry or wet.
Each Electronic Engine Control (EEC) can control the starting and ignition components according to cockpit commands and protective logics.
The main engine parameters to be monitored during starting are displays on the Engine/Warning Display (E/WD) (N1, EGT, N2, Fuel Flow) and on the System Display (SD) (Oil Press, IGN system, Starter Air Valve (SAV) position and available pneumatic pressure).
There are two separate redundant ignition systems per engine. Each system is made up of one ignition exciter, one ignition lead and one igniter plug. Each of the two plugs and corresponding circuits can be used both at the same time or alternately to detect dormant failures.
The Engine Interface Unit (EIU) supplies 115 Volt power supply to both EECs for ignition.
The EECs control the ignition via internal high voltage relays to supply 115 VAC to the ignition exciters.
The starting system consists of a SAV, Starter Air Duct (SAD) and an Air Turbine Starter (ATS).
The SAV is a butterfly valve, electrically controlled by the EECs and pneumatically operated.
The SAV operation is monitored by the EECs by means of a dual pressure sensor.
The ATS is attached to the front of the Accessory Gearbox (AGB) at the 7 o'clock position. It is controlled and monitored by the EECs according to the engine speed.

The pressurized air supply to the starting components is provided by one of the following sources:
- Auxiliary Power Unit (APU) bleed,
- external pneumatic ground cart,
- engine bleed from the opposite engine.


ECAM EWD
N1
%
XX
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
AIR
115 VAC
RELAY
EEC A
EEC B
EXCITER 1
EXCITER 2
IGNITER A
IGNITER B
FMU
FMV
HPSOV
TM
FFM
IGNITER PLUGS
A
B
EXCITER1
EXCITER2
ATS
SAV
N1
N2
PRESS
EGT
FF
SAME PRINCIPLE FOR EEC B
ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

GENERAL


ECAM EWD
N1
%
XX
EGT
°C
N2
%
FF
KG / H
FOB: 16800 KG
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
ENG 2
MODE
NORM
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
ON
AIR
FUEL
M
LP SOV
FMU
FMV
HPSOV
T M
FFM
IGNITER PLUGS
A
B
*
S
ATS
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

GENERAL

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IGNITION AND STARTING SYSTEM D/O (ME)

AUTOMATIC START

The EEC shall enter the automatic start mode when all of the following conditions are true:
- the engine is not running, and
- the ENG MODE rotary selector is set to IGN/START, and
- the ENG MASTER lever is set to ON, and
- the ENG MAN START pushbutton is OFF.

When the ENG MODE rotary selector is set to IGN/START position, FADEC is powered up.

The ENGINE page is automatically shown on the System Display (SD) page of the ECAM system.

The ENGINE page displays the IGN indication, SAV position and bleed pressure during this sequence.

At the same time, the APU bleed demand will increase and the pack valves will close.

As soon as the ENG MASTER lever is set to ON position, the Low Pressure Shut Off Valve (LPSOV) opens and the automatic starting sequence begins.

The EEC will automatically control the:
- Start Bleed Valve (opening and closing) if necessary during ground engine start or in flight restart,
- Hydraulic pump depressurizing (via EIU) if necessary during in flight restart,
- SAV (opening and closing),
- Igniters (one or two, on and off),
- Fuel Flow (FF) (Fuel Metering Valve (FMV) and High Pressure Shut Off Valve (HPSOV) opening).

First, the EEC energizes the SAV solenoid. This supplies the starter with aircraft pneumatic pressure.

The position of the SAV is confirmed open at the bottom of the ENGINE page thanks to the SAV dual pressure sensor feedback.

Consequently, the N2 begins to increase.

When the engine reaches 15% of N2, the EEC in control activates one igniter (A or B), which is displayed on the SD ENGINE page.

Then at 20% of N2, the active EEC controls the appropriate Fuel Flow (FF) to the burner. On the E/WD, the FF increases.

Fuel is sent to the burner via the FMV and the HPSOV in the Fuel Metering Unit (FMU) and the Pilot Metering Valve (PMV) in the SCU/SVA.

In automatic start mode, the FADEC has the full authority on the control of the igniters, fuel, and SAV.

The EEC monitors the Exhaust Gas Temperature (EGT) and N2 according to their schedules to provide the correct fuel flow for a good acceleration.

When N2 reaches 55%, the EEC controls the igniter to OFF.

When N2 reaches 60%, the EEC controls the SAV to close.

The engine continues to accelerate and stabilizes at idle speed.

The usual standard parameters are:
- N1 = 19%,
- N2 = 60%,
- EGT = 440 ºC,
- FF = 227 kg/h.

If the second engine has to be started, the ENG MODE rotary selector should stay on the IGN/START position.

This will avoid activating the continuous ignition on the running engine if the selector is cycled to NORM and again to IGN/START.

When both engines are running, the selector is set back to NORM, the WHEEL page will appear instead of the ENGINE page if at least one engine running.

Pilot initiated abortion:

On the ground or in flight, the automatic start sequence can be manually aborted by selecting the ENG MASTER lever to the OFF position.

This leads to:
- SAV closure,
- Igniter(s) off,
- FMV, LPSOV and HPSOV closure.

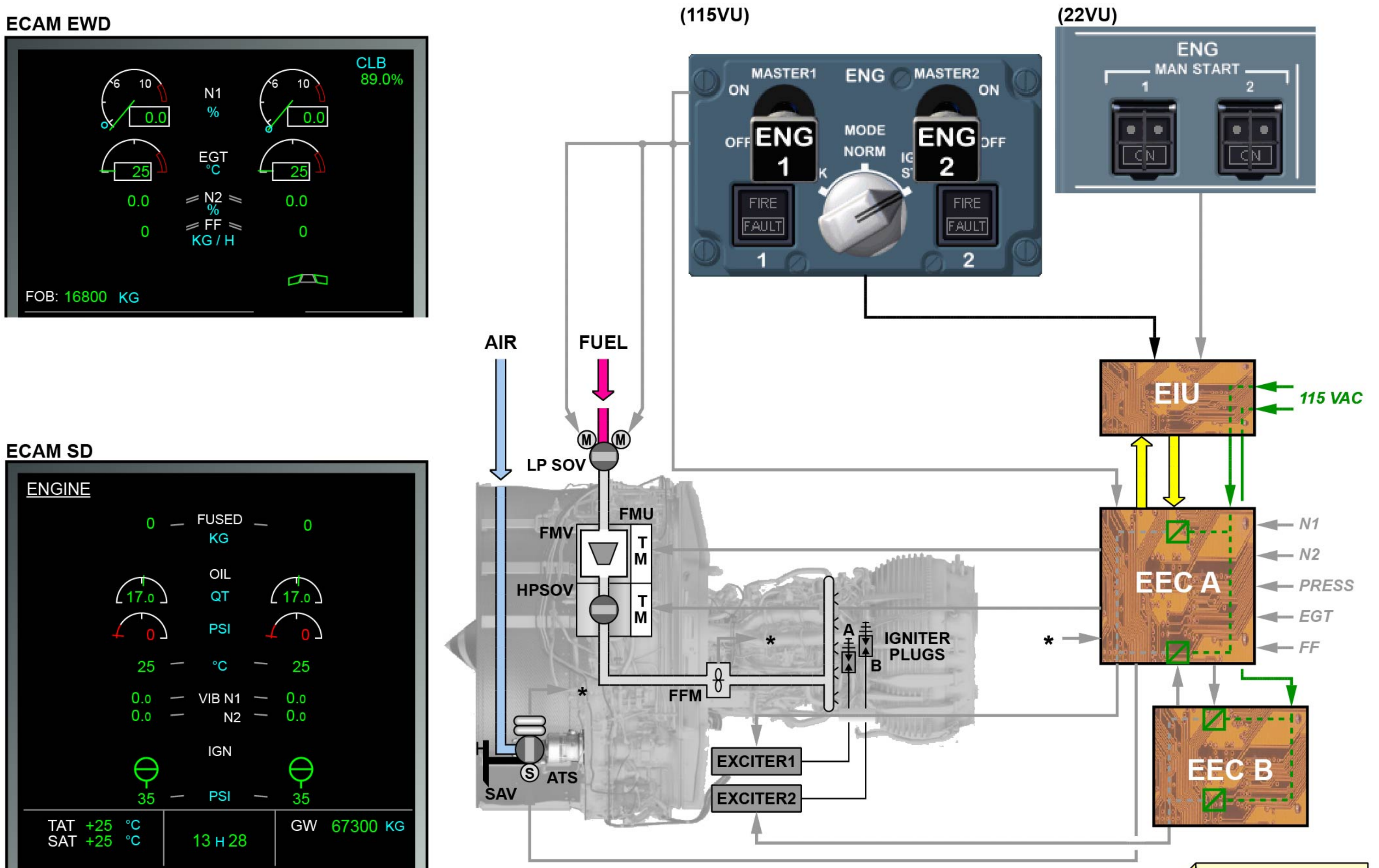
NOTE: EEC does not dry motor the engine when an automatic start is manually aborted.

Automatic protection:

On the ground, the EEC has the authority:

- to abort a start only in case of severe malfunction or
- to perform a maximum of three start attempts in case of minor fault. In this case, the EEC will abort the start, dry motor the engine and attempt a new start.

In flight, the EEC cannot abort a start but it can accommodate or provide fault annunciation.


ECAM EWD
CLB
89.0%
N1
%
0.0
0.0
EGT
°C
25
25
N2
%
0.0
0.0
FF
KG / H
0
0
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
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OIL
QT
17.0
17.0
PSI
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VIB N1
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N2
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PSI
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TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
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MASTER2
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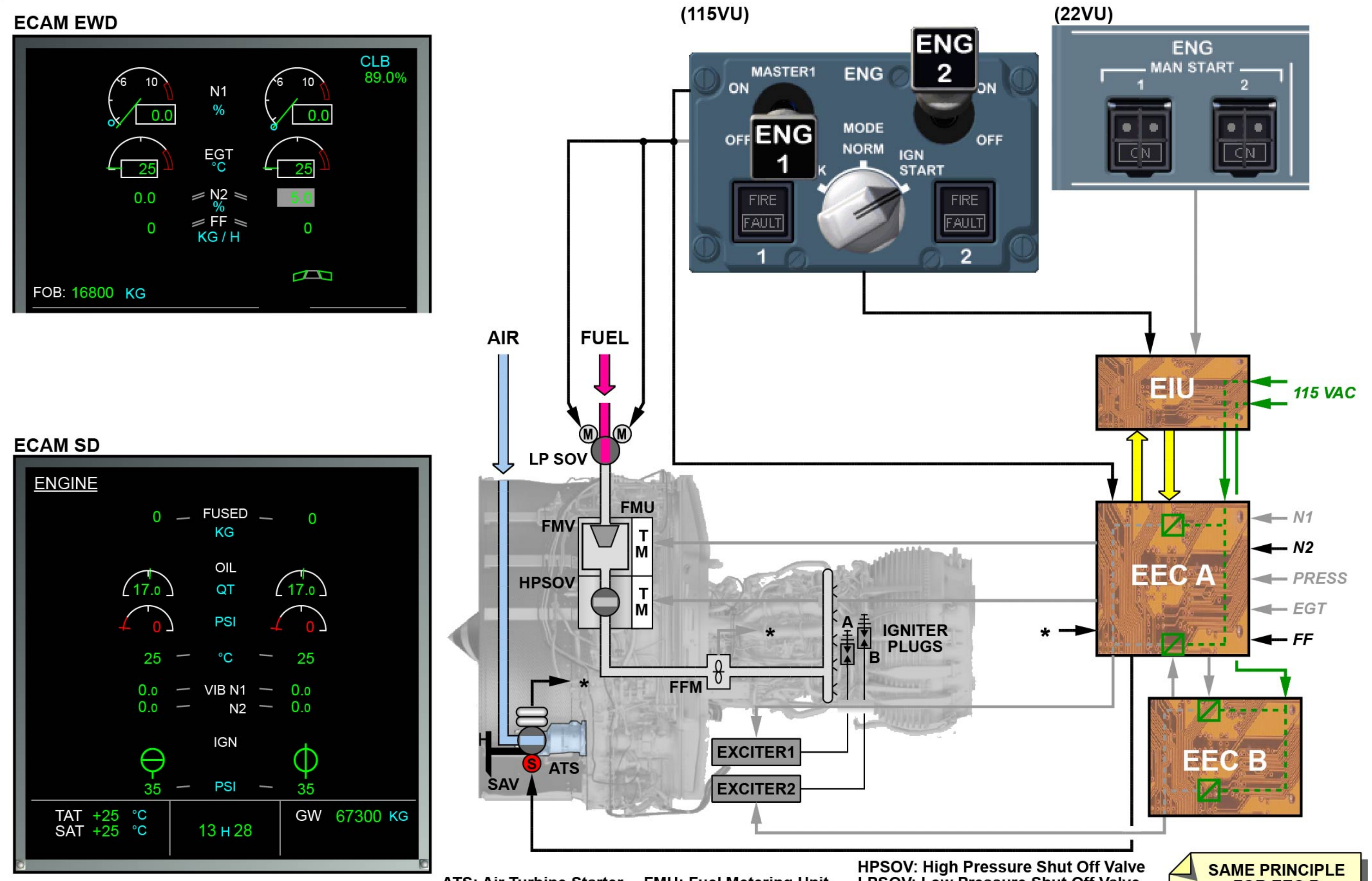
ON
OFF
ENG 1
MODE
NORM
ENG 2
OFF
FIRE
FAULT
1
FIRE
FAULT
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
LP SOV
FMU
FMV
T M
HPSOV
T M
FFM
*
IGNITER PLUGS
A
B
EXCITER1
EXCITER2
ATS
SAV
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

AUTOMATIC START


ECAM EWD
CLB
89.0%
N1
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0.0
0.0
EGT
°C
25
25
0.0
N2
%
FF
KG / H
0
0
FOB: 16800 KG
ECAM SD
ENGINE
FUSED
KG
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OIL
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VIB N1
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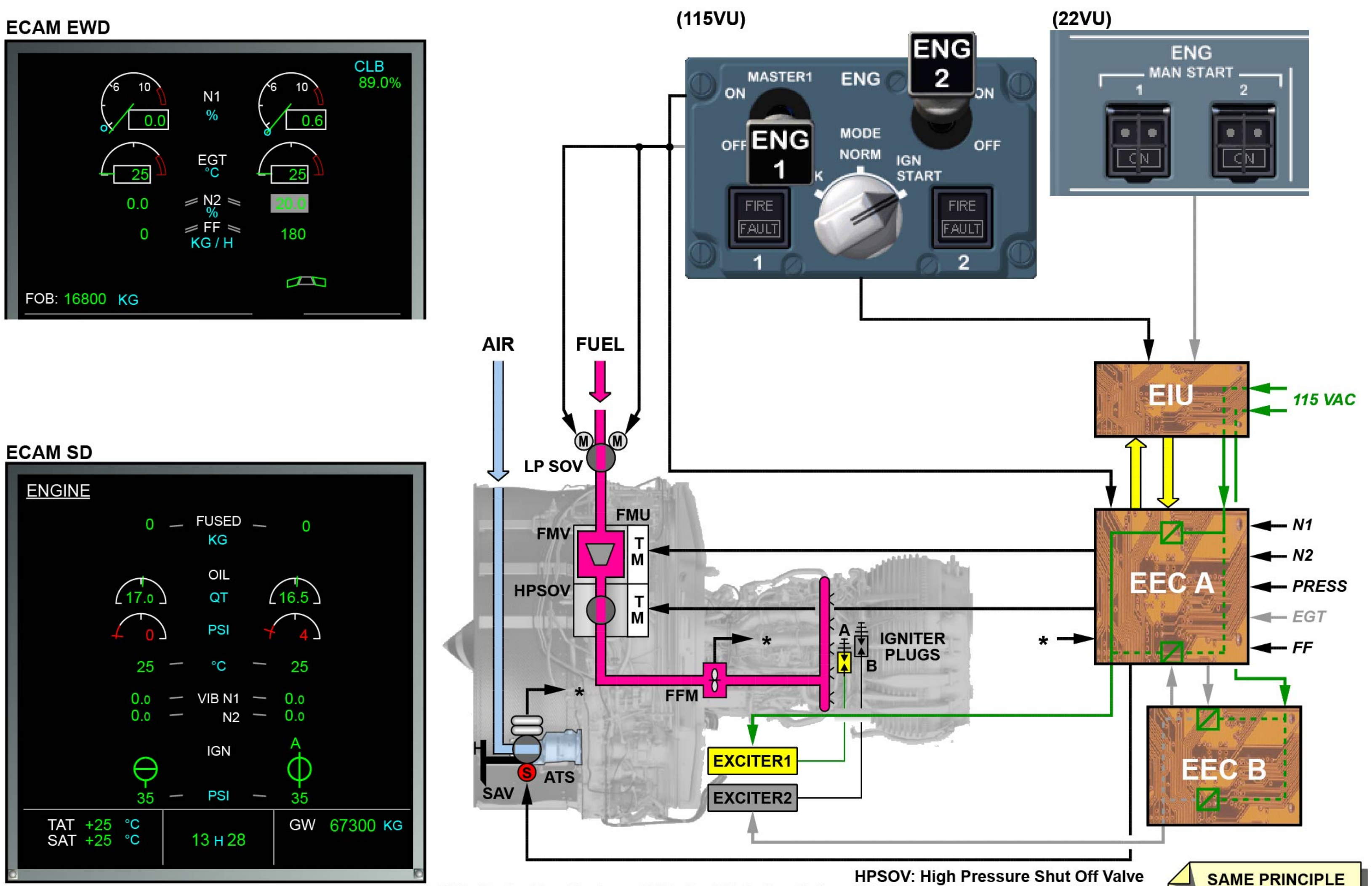
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ON
ENG
ENG 2
ON
OFF
ENG 1
MODE
NORM
IGN
START
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
LP SOV
M
M
FMU
FMV
T M
HPSOV
T M
FFM
*
A
B
IGNITER PLUGS
EXCITER1
EXCITER2
ATS
SAV
S
*
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

AUTOMATIC START


ECAM EWD
CLB
89.0%
N1
%
6
10
0.0
0.6
EGT
°C
25
25
0.0
N2
%
20.0
0
FF
KG / H
180
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
16.5
PSI
0
4
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
A
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
ENG
2
ON
OFF
ENG
1
MODE
NORM
OFF
IGN
START
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T
M
HPSOV
T
M
*
*
FFM
A
B
IGNITER
PLUGS
ATS
S
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B
SAME PRINCIPLE
FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
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HPSOV: High Pressure Shut Off Valve
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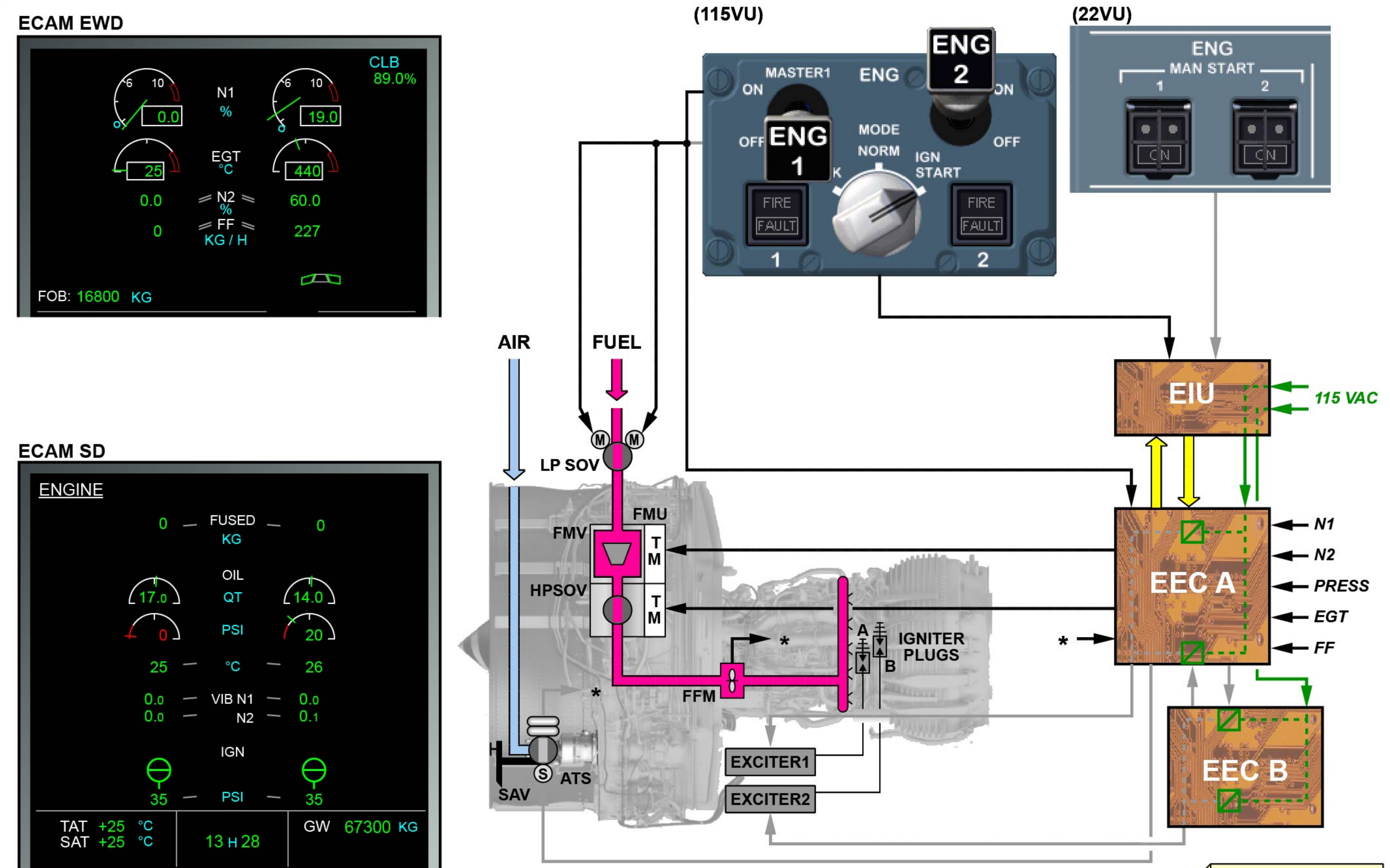
SAV: Starter Air Valve

AUTOMATIC START


ECAM EWD
CLB
89.0%
6
10
0.0
N1
%
19.0
25
EGT
°C
440
0.0
N2
%
60.0
0
FF
KG / H
227
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
14.0
PSI
0
20
25
°C
26
0.0
VIB N1
0.0
0.0
N2
0.1
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ON
ENG
ENG
2
ON
OFF
ENG
1
MODE
NORM
IGN
START
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T
M
HPSOV
T
M
A
IGNITER
PLUGS
B
*
FFM
*
H
S
ATS
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B

SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

AUTOMATIC START

IGNITION AND STARTING SYSTEM D/O (ME)

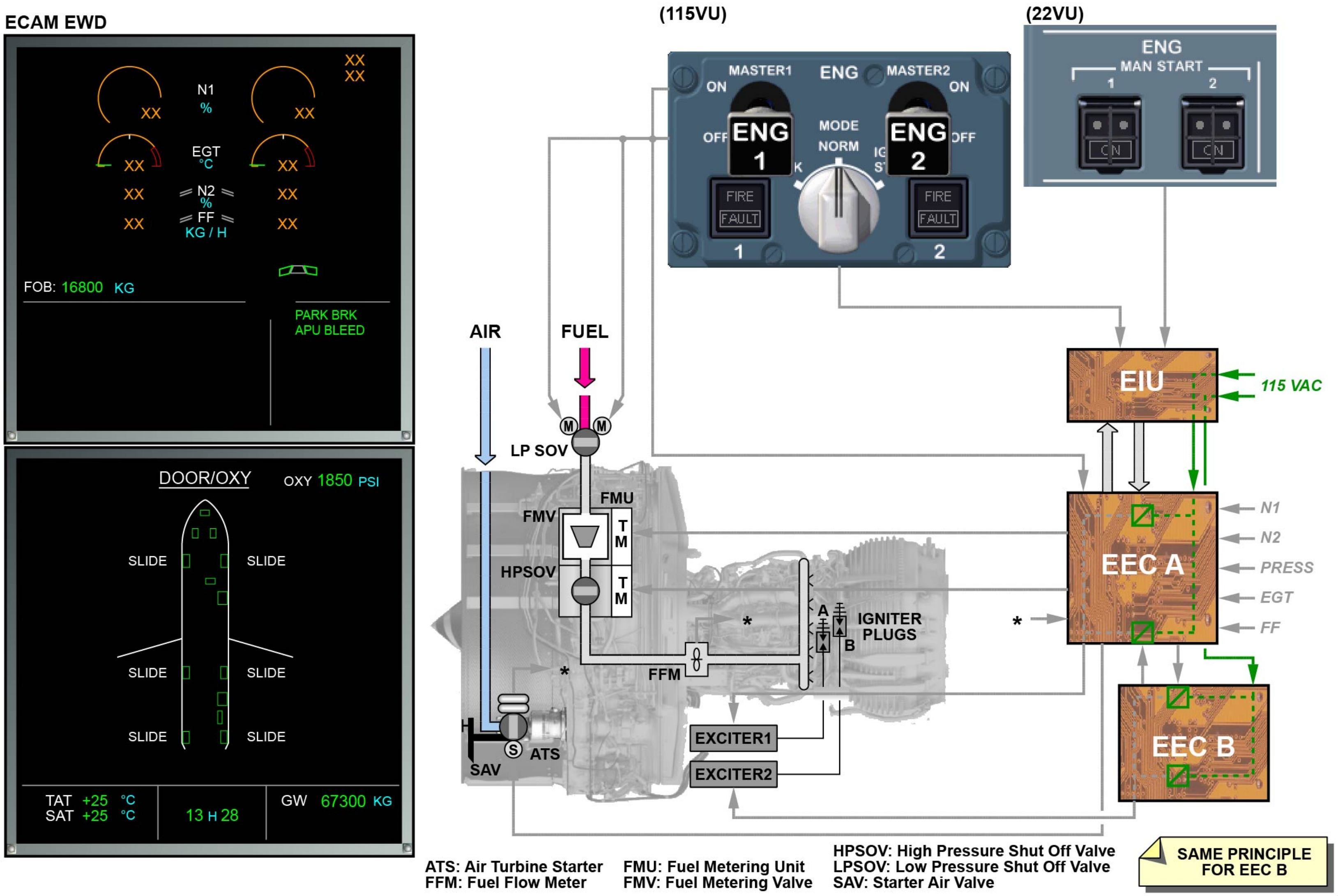
MANUAL START

A manual engine start procedure is included in the EECs engine starting logic for ground or flight condition.
In the manual start mode, engine starting control is under limited authority of the engaged EEC.
The SAV, fuel, and ignition are controlled from the cockpit via the EEC.
Bleed air source being available, a manual start sequence is commanded by first setting the rotary selector to the IGN/START position to power and signal the EEC.
The ENGINE page appears on the SD page of the ECAM.
The ENGINE page displays the IGN indication, SAV position and bleed pressure during this sequence.
At the same time, the APU bleed demand will increase and the pack valves will close.
The next action is to engage the ENG MAN START push-button to the ON position. This will lead the EEC to open the SAV.
When N2 is above the minimum fuel pressurization speed (on-ground approximately 20% N2), the ENG MASTER lever is set to the ON position. The EEC commands fuel flow and both igniters simultaneously.
The EEC monitors the EGT and N2 according to their schedules to provide the correct fuel flow but EGT limit protection is inactive.
When N2 reaches 55% N2, the EEC de-energizes the ignition system.
At 60%, the SAV will be controlled to close.
The engine continues to accelerate and stabilizes at idle speed.
Pilot initiated abortion:
When a manual engine start has been initiated on ground or in flight, it shall be interrupted by either:
- de-selecting the ENG MAN START push-button before the ENG MASTER lever is commanded ON, or
- selecting ENG MASTER lever back to OFF position after it has already been selected ON.

Interruption of a manual start shall result in the following EEC commands:
- SAV closure,
- igniters off,
- FMV and HP fuel shut-off valve closure.

Automatic protection:
On the ground, the EEC has the authority
- to abort a start only in case of severe malfunction or
- to perform a maximum of three start attempts in case of minor fault. In this case, the EEC will abort the start, dry motor the engine and attempt a new start.

In flight, the EEC cannot abort a start but it can accommodate or provide fault annunciation.

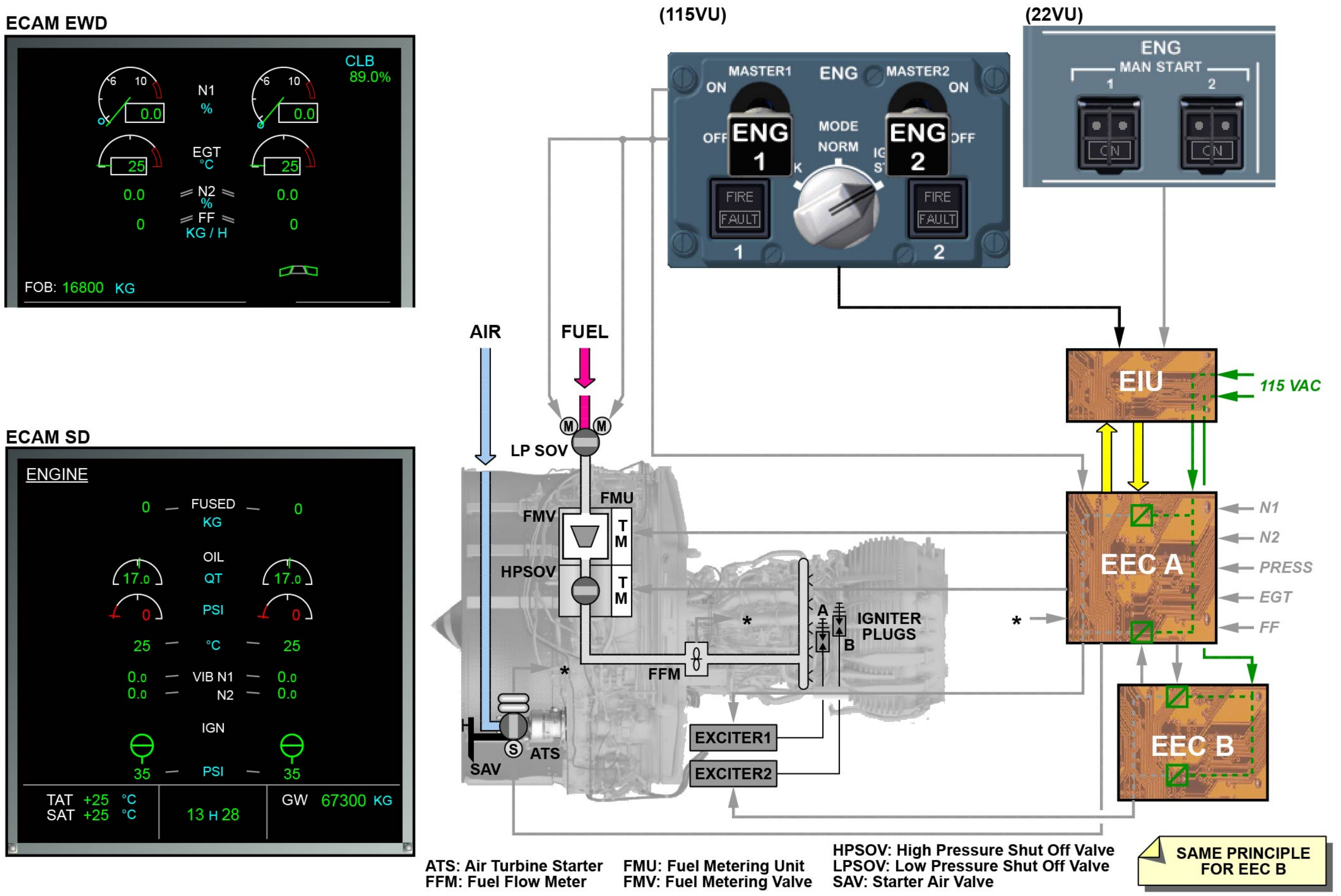

ECAM EWD
XX
XX
N1
%
XX
XX
EGT
°C
XX
XX
XX
N2
%
XX
XX
FF
KG / H
XX
FOB: 16800 KG
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
ON
OFF
ENG 1
MODE
NORM
IG ST
ENG 2
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T M
HPSOV
T M
*
A
B
IGNITER PLUGS
*
FFM
*
ATS
S
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

MANUAL START


ECAM EWD
CLB
89.0%
N1
%
6
10
0.0
0.0
EGT
°C
25
25
0.0
N2
%
0.0
0
FF
KG / H
0
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
17.0
PSI
0
0
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
ON
OFF
ENG 1
MODE
NORM
ENG 2
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T M
HPSOV
T M
FFM
*
*
*
A
B
IGNITER PLUGS
EXCITER1
EXCITER2
S
ATS
SAV
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE FOR EEC B

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FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
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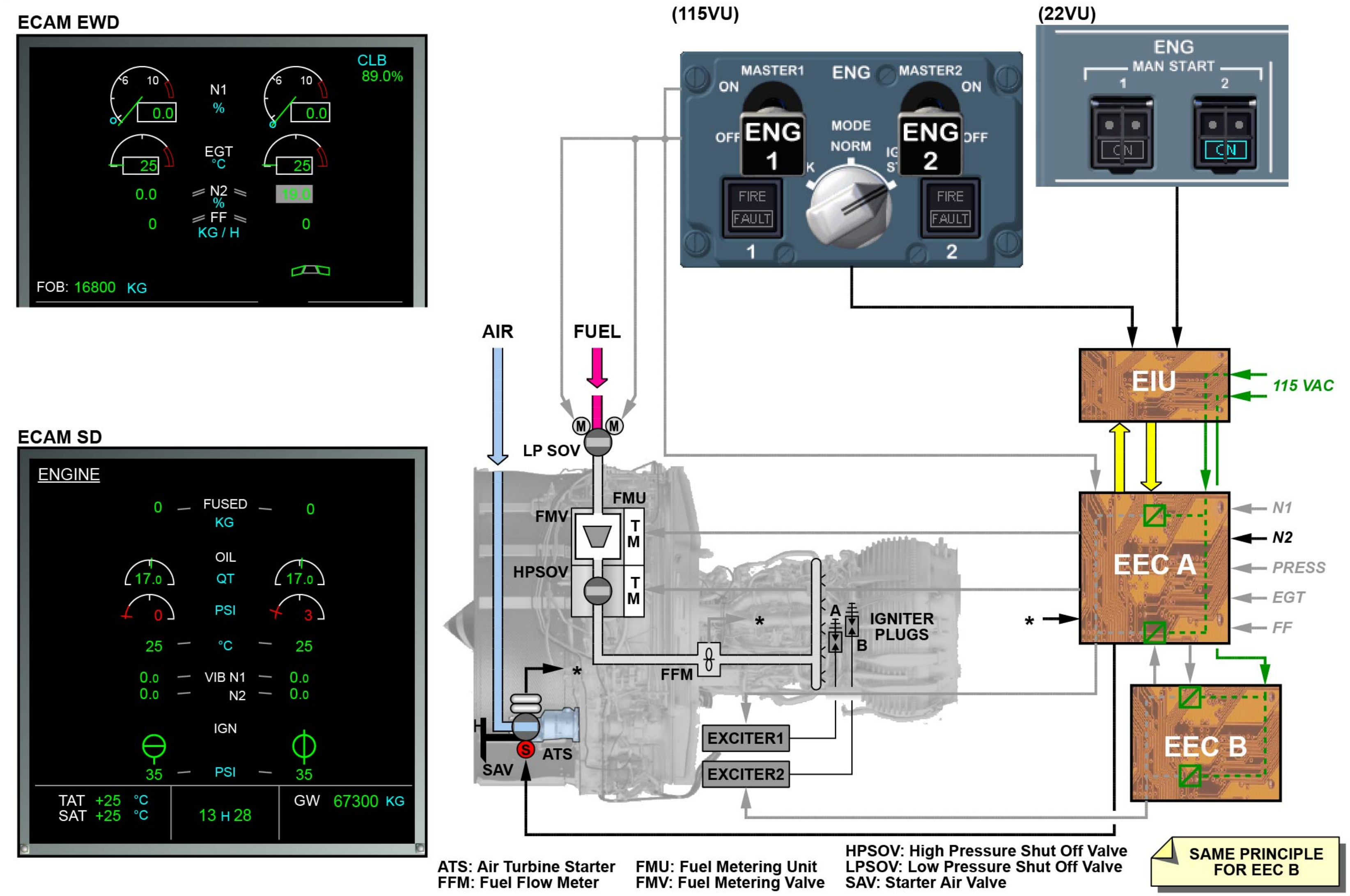
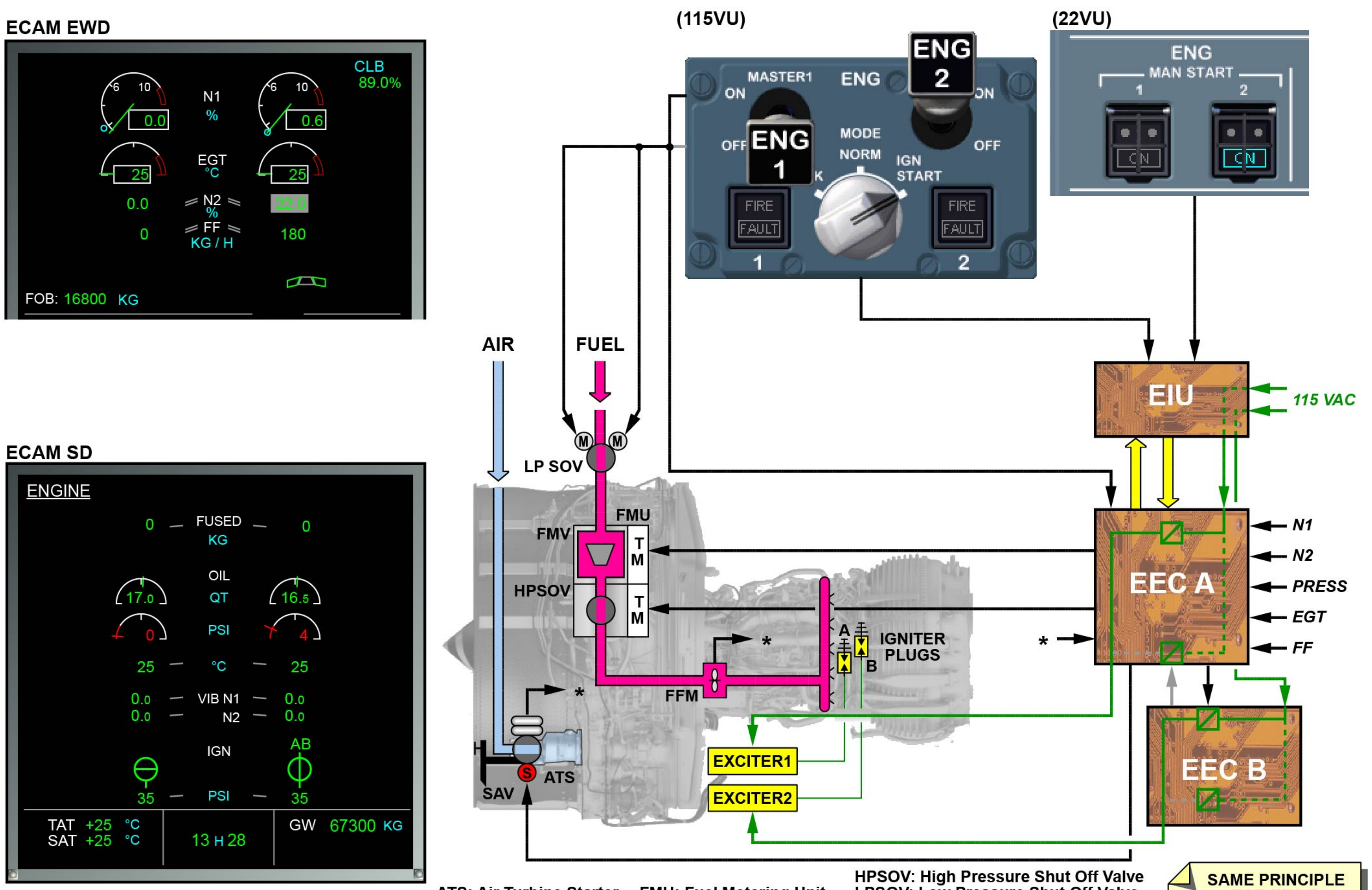
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

MANUAL START


ECAM EWD
CLB
89.0%
N1
%
0.0
0.0
EGT
°C
25
25
N2
%
0.0
19.0
FF
KG / H
0
0
FOB: 16800 KG
ECAM SD
ENGINE
FUSED
KG
0
0
OIL
QT
17.0
17.0
PSI
0
3
°C
25
25
VIB N1
N2
0.0
0.0
0.0
0.0
IGN
PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
ENG 2
MODE
NORM
FIRE FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T M
HPSOV
T M
FFM
*
A
B
IGNITER PLUGS
EXCITER1
EXCITER2
SAV
ATS
S
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

MANUAL START


ECAM EWD
CLB
89.0%
N1
%
0.0
0.6
EGT
°C
25
25
0.0
N2
%
22.0
0
FF
KG / H
180
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
16.5
PSI
0
4
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
AB
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
ENG 2
ON
OFF
ENG 1
MODE
NORM
IGN START
OFF
FIRE FAULT
FIRE FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
LP SOV
M
M
FMU
FMV
T M
HPSOV
T M
IGNITER PLUGS
A
B
*
FFM
*
*
ATS
SAV
S
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

MANUAL START

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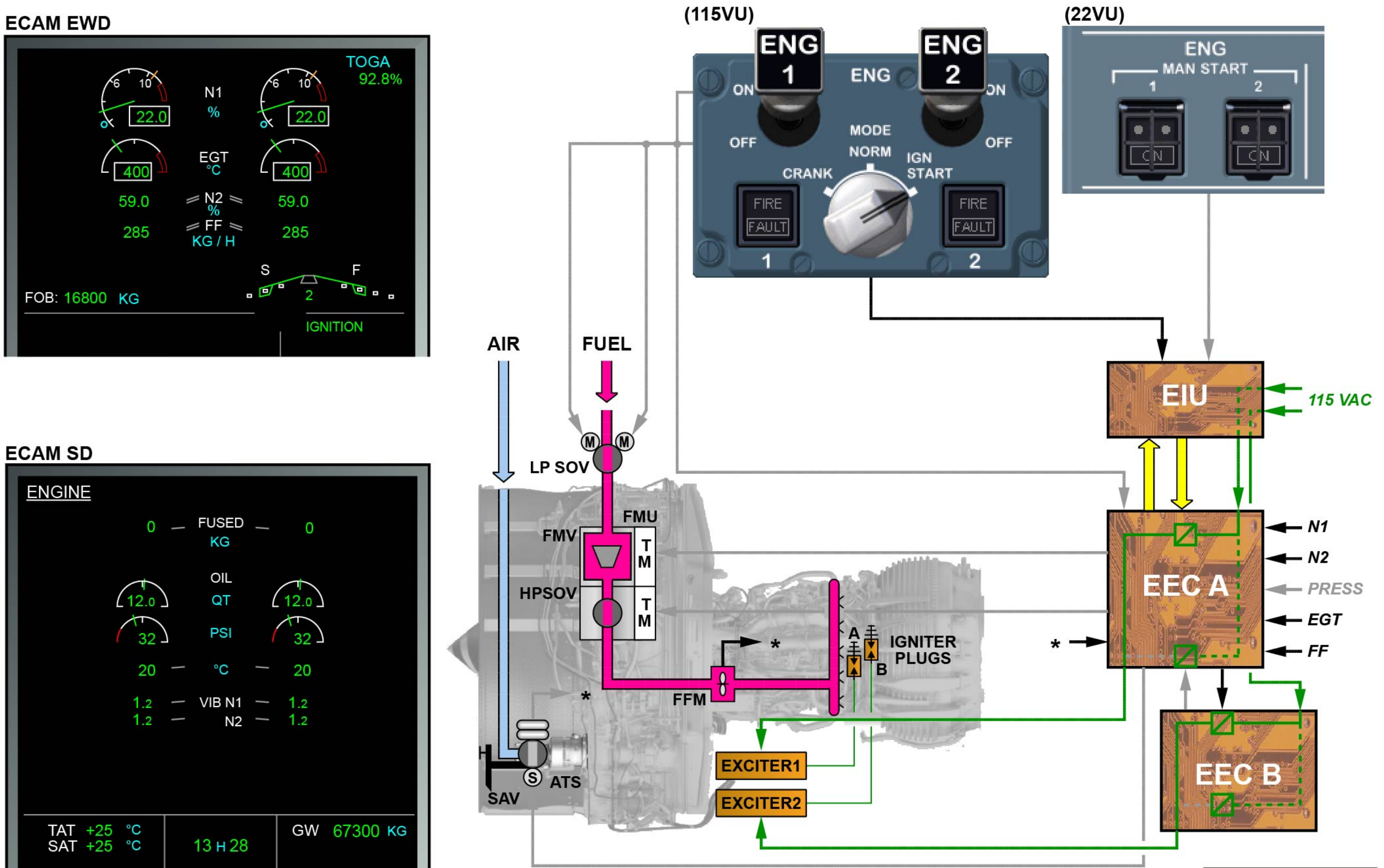
IGNITION AND STARTING SYSTEM D/O (ME)

CONTINUOUS IGNITION

Continuous ignition is manually selected or automatically controlled by the FADEC.
During continuous ignition both igniters are active.
Manual command:
Once the engine is running above idle, the pilot can manually command continuous ignition at any time by moving the rotary selector to the IGN/START position.
Following a ground start, the rotary selector must be moved back to NORM before continuous ignition can be manually selected by moving it back to IGN/START position.
Continuous ignition shall remain commanded by the EEC until the rotary selector is moved back to NORM or until the combustor pressure (PS3) is greater than or equal to 175 psia.
Automatic command:
The EEC automatically commands continuous ignition when an engine flameout is detected in flight and PS3 is less than 175 psia even if the rotary selector is not set to the IGN/START position.


ECAM EWD
TOGA
92.8%
N1
%
22.0
22.0
EGT
°C
400
400
59.0
59.0
N2
%
FF
KG / H
285
285
S
F
2
FOB: 16800 KG
IGNITION
ECAM SD
ENGINE
FUSED
KG
0
0
OIL
QT
12.0
12.0
PSI
32
32
°C
20
20
VIB N1
N2
1.2
1.2
1.2
1.2
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
ENG 1
ENG 2
ENG
ON
ON
OFF
OFF
MODE
NORM
CRANK
IGN START
FIRE FAULT
FIRE FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
LP SOV
M
M
FMU
FMV
HPSOV
T M
T M
FFM
*
*
*
A
B
IGNITER PLUGS
EXCITER1
EXCITER2
ATS
SAV
S
H
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B

SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

CONTINUOUS IGNITION

IGNITION AND STARTING SYSTEM D/O (ME)

ENGINE CRANK

DRY CRANK

Cranking function is used to motor the engine on the ground for a short time with the use of the starter.

There are two cranking modes:
- dry cranking,
- wet cranking.

The dry cranking procedure is used to motor the engine to remove unburned fuel from the combustion chamber or cool down the engine or for some fuel or oil leak tests.

The EEC shall enter the engine dry crank sequence when all of the following conditions are true:
- the engine is not running and,
- the aircraft is on ground and,
- the rotary selector is set to CRANK.

This will power up the EECs and isolate both ignition systems.

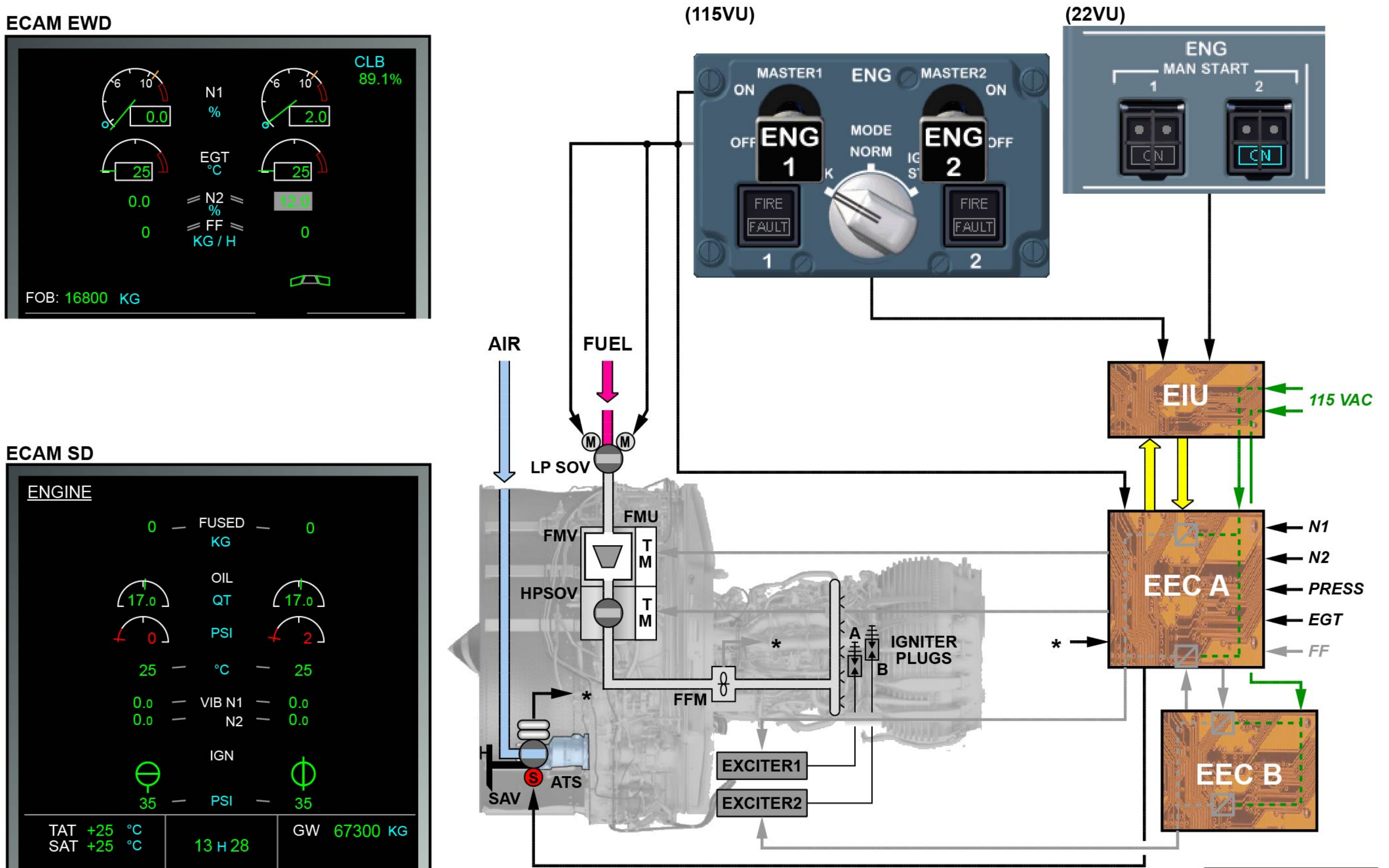
The ENGINE page appears automatically on the ECAM SD.

When the ENG MAN START P/B is set to ON, the EEC commands the SAV to open.

The dry motoring can be interrupted at any time by pushing the ENG MAN START pushbutton to OFF or positioning the ENG MODE rotary selector to NORM position.

The usual starter duty cycle is 3 starter crank cycles or 5 minutes maximum of continuous cranking. A 30 minutes cool down period is necessary for additional use.

WARNING: the EEC is able to initiate a start sequence immediately following a dry motoring sequence by setting the ENG MODE rotary selector to IGN/START position and the ENG MASTER control lever to ON position.


ECAM EWD
CLB
89.1%
N1
%
0.0
2.0
EGT
°C
25
25
0.0
N2
%
12.0
0
FF
KG / H
0
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
17.0
PSI
0
2
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
MASTER2
ON
ON
OFF
ENG 1
MODE
NORM
ENG 2
OFF
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T M
HPSOV
T M
*
A
B
IGNITER PLUGS
FFM
*
H
SAV
S
ATS
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

SAME PRINCIPLE FOR EEC B

ENGINE CRANK - DRY CRANK

IGNITION AND STARTING SYSTEM D/O (ME)

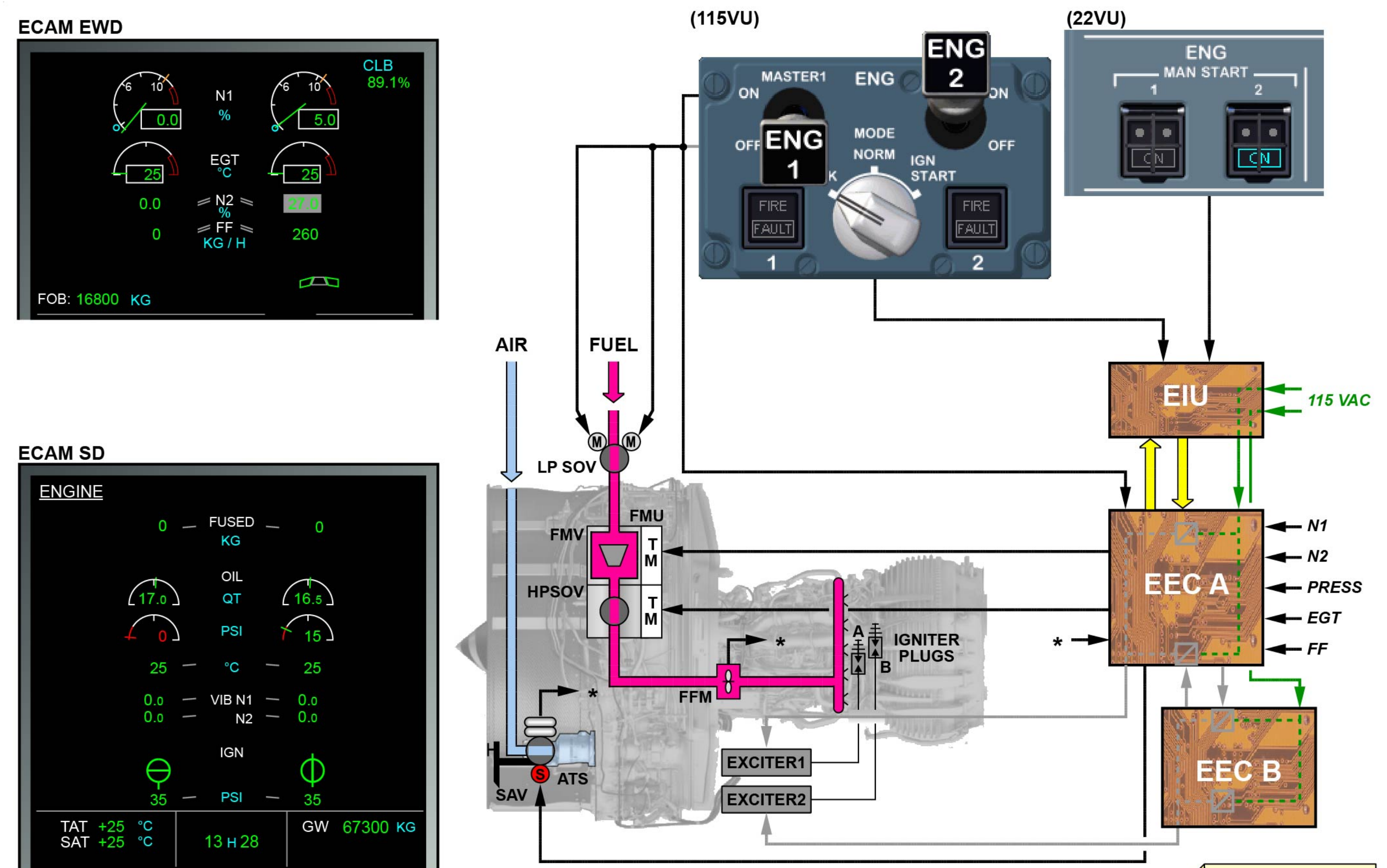
ENGINE CRANK (continued)

WET CRANK

The wet cranking procedure is used to motor the engine for specific fuel leak tests.
The fuel flow is commanded but both ignition systems are isolated.
The fuel goes through the FMU and the SCU/SVA to the actuator fuel pressure lines, the engine fuel manifolds (primary fuel lines only), and nozzles. Fuel is then sprayed in the combustion chamber.
The first steps of the wet crank sequence are the same as the ones for the dry crank:

- the engine is not running,
- the aircraft is on ground,
- the rotary selector is set to CRANK (EECs powered, both ignition systems isolated, ENGINE page appears),
- the ENG MAN START P/B is set to ON (SAV opening).

When N2 speed stabilizes, the ENG MASTER lever is set to the ON position to command the fuel flow.
After 15 seconds, the ENG MASTER lever is set to the OFF position to cut the fuel supply.
The SAV command is maintained 30 seconds to blow all the fuel from the engine.
The wet motoring ends by pushing the ENG MAN START pushbutton to OFF or/and positioning the ENG MODE rotary selector to NORM position.


ECAM EWD
CLB
89.1%
6 10
0.0
N1
%
6 10
5.0
EGT
°C
25
25
0.0
N2
%
27.0
0
FF
KG / H
260
FOB: 16800 KG
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
16.5
PSI
0
15
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
ENG 2
ON
OFF
ENG 1
MODE
NORM
IGN
START
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T M
HPSOV
T M
*
*
*
A
B
IGNITER PLUGS
FFM
ATS
SAV
S
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B

SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

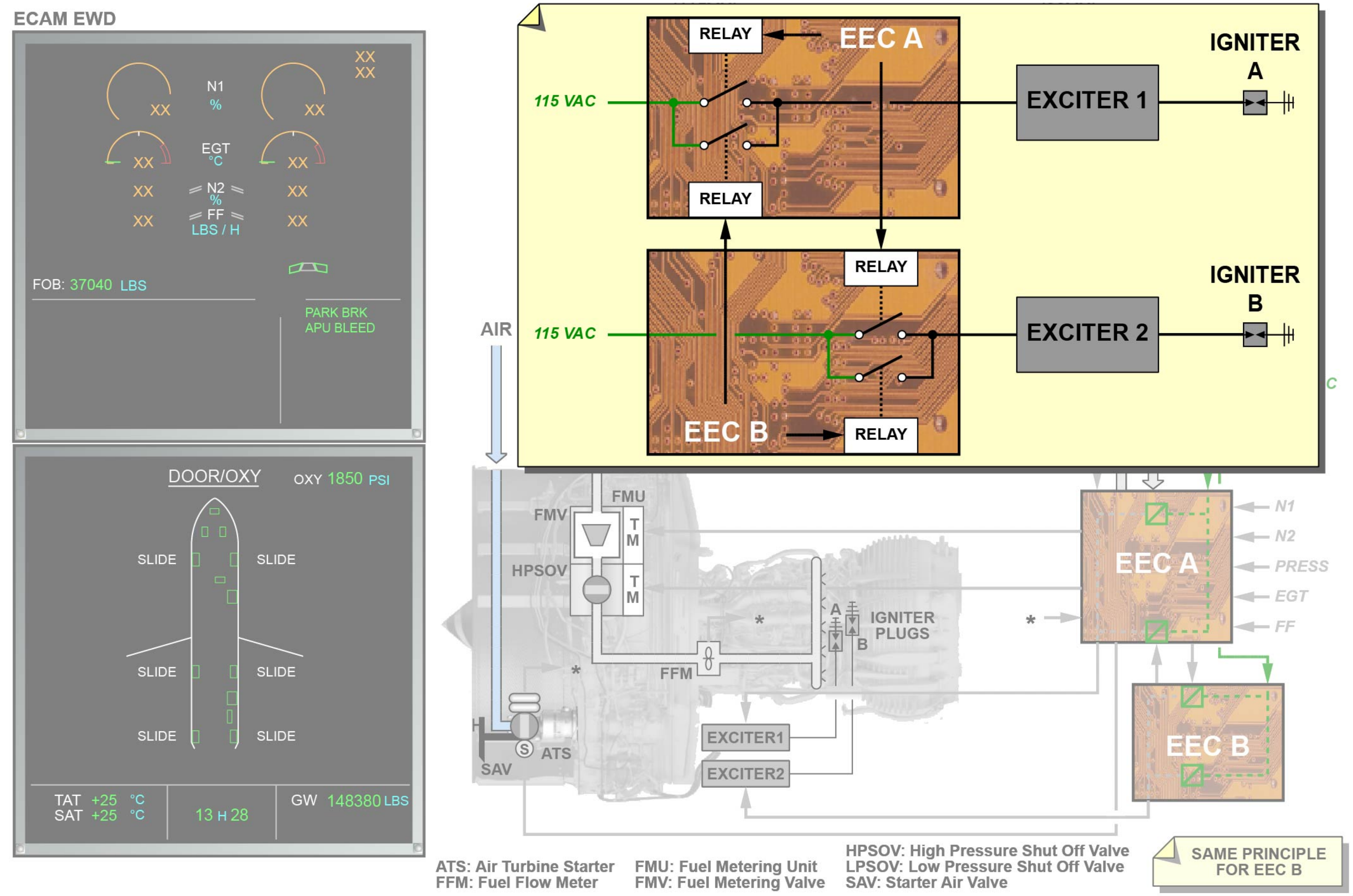
ENGINE CRANK - WET CRANK

IGNITION AND STARTING SYSTEM D/O (US)

GENERAL

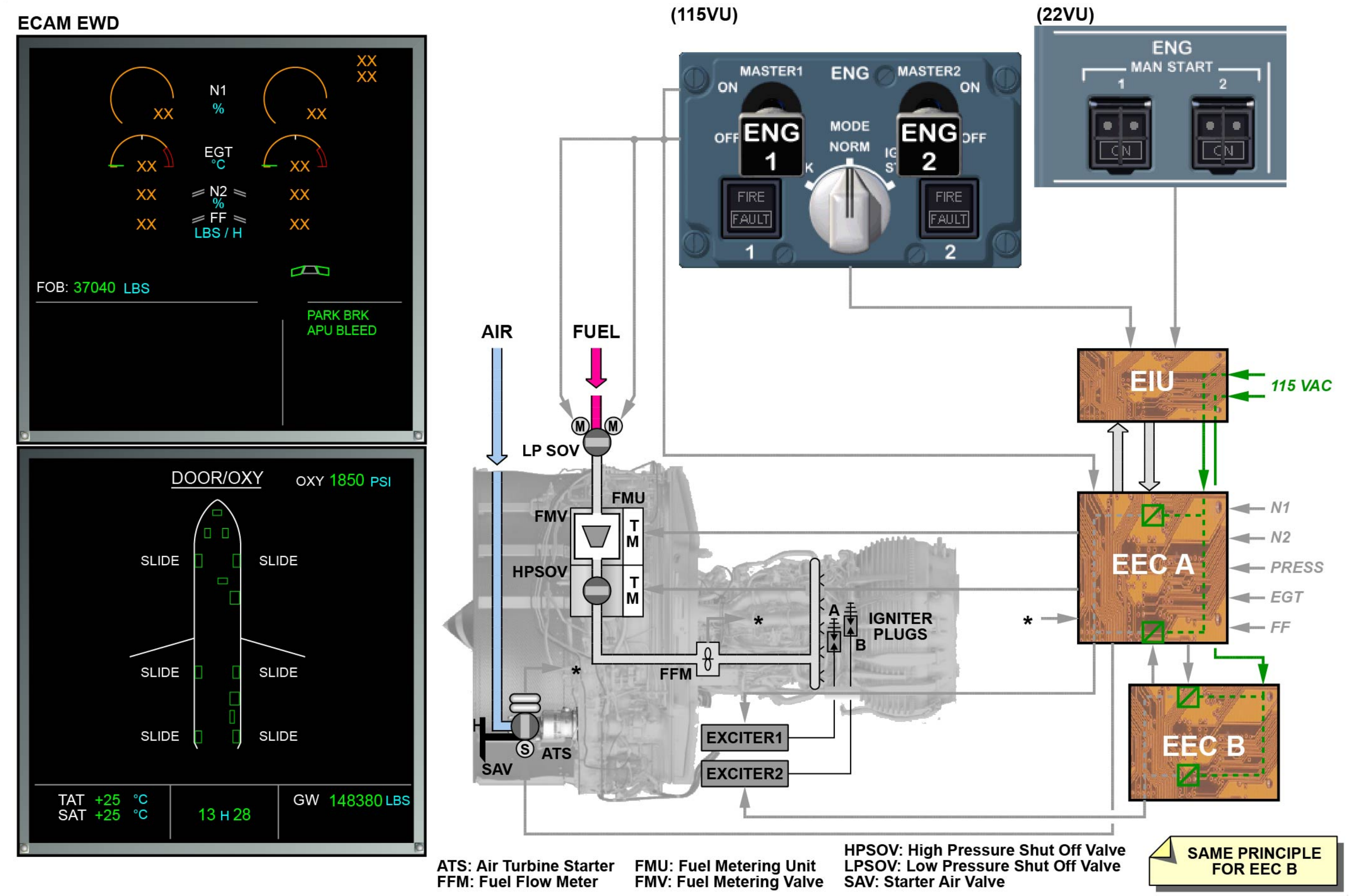
The FADEC controls and monitors the Starting and Ignition systems for engine starting, cranking, and ignition selection, on ground and in flight.
For engine starting, two modes are available; automatic or manual.
Both modes can be used on ground or in flight but the in-flight sequences are less protective to enhance the restart capability.
For engine cranking, two sequences can be manually selected: dry or wet.
Each Electronic Engine Control (EEC) can control the starting and ignition components according to cockpit commands and protective logics.
The main engine parameters to be monitored during starting are displays on the Engine/Warning Display (E/WD) (N1, EGT, N2, Fuel Flow) and on the System Display (SD) (Oil Press, IGN system, Starter Air Valve (SAV) position and available pneumatic pressure).
There are two separate redundant ignition systems per engine. Each system is made up of one ignition exciter, one ignition lead and one igniter plug. Each of the two plugs and corresponding circuits can be used both at the same time or alternately to detect dormant failures.
The Engine Interface Unit (EIU) supplies 115 Volt power supply to both EECs for ignition.
The EECs control the ignition via internal high voltage relays to supply 115 VAC to the ignition exciters.
The starting system consists of a SAV, Starter Air Duct (SAD) and an Air Turbine Starter (ATS).
The SAV is a butterfly valve, electrically controlled by the EECs and pneumatically operated.
The SAV operation is monitored by the EECs by means of a dual pressure sensor.
The ATS is attached to the front of the Accessory Gearbox (AGB) at the 7 o'clock position. It is controlled and monitored by the EECs according to the engine speed.

The pressurized air supply to the starting components is provided by one of the following sources:
- Auxiliary Power Unit (APU) bleed,
- external pneumatic ground cart,
- engine bleed from the opposite engine.


ECAM EWD
XX
XX
N1
%
XX
XX
EGT
°C
XX
XX
N2
%
XX
XX
FF
LBS / H
XX
XX
FOB: 37040 LBS
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
RELAY
EEC A
RELAY
115 VAC
EXCITER 1
IGNITER A
RELAY
115 VAC
EXCITER 2
IGNITER B
EEC B
RELAY
AIR
FMU
FMV
T M
HPSOV
T M
IGNITER PLUGS
A
B
FFM
ATS
SAV
EXCITER1
EXCITER2
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

GENERAL


ECAM EWD
XX
XX
N1
%
XX
XX
EGT
°C
XX
XX
XX
N2
%
XX
XX
FF
LBS / H
XX
FOB: 37040 LBS
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
MASTER2
ON
ON
OFF
ENG 1
MODE
NORM
ENG 2
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T M
HPSOV
T M
*
*
A
B
IGNITER PLUGS
*
FFM
S
ATS
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

GENERAL

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IGNITION AND STARTING SYSTEM D/O (US)

AUTOMATIC START

The EEC shall enter the automatic start mode when all of the following conditions are true:
- the engine is not running, and
- the ENG MODE rotary selector is set to IGN/START, and
- the ENG MASTER lever is set to ON, and
- the ENG MAN START pushbutton is OFF.

When the ENG MODE rotary selector is set to IGN/START position, FADEC is powered up.
The ENGINE page is automatically shown on the System Display (SD) page of the ECAM system.
The ENGINE page displays the IGN indication, SAV position and bleed pressure during this sequence.
At the same time, the APU bleed demand will increase and the pack valves will close.
As soon as the ENG MASTER lever is set to ON position, the Low Pressure Shut Off Valve (LPSOV) opens and the automatic starting sequence begins.
The EEC will automatically control the:
- Start Bleed Valve (opening and closing) if necessary during ground engine start or in flight restart,
- Hydraulic pump depressurizing (via EIU) if necessary during in flight restart,
- SAV (opening and closing),
- Igniters (one or two, on and off),
- Fuel Flow (FF) (Fuel Metering Valve (FMV) and High Pressure Shut Off Valve (HPSOV) opening).

First, the EEC energizes the SAV solenoid. This supplies the starter with aircraft pneumatic pressure.
The position of the SAV is confirmed open at the bottom of the ENGINE page thanks to the SAV dual pressure sensor feedback.
Consequently, the N2 begins to increase.
When the engine reaches 15% of N2, the EEC in control activates one igniter (A or B), which is displayed on the SD ENGINE page.
Then at 20% of N2, the active EEC controls the appropriate Fuel Flow (FF) to the burner. On the E/WD, the FF increases.
Fuel is sent to the burner via the FMV and the HPSOV in the Fuel Metering Unit (FMU) and the Pilot Metering Valve (PMV) in the SCU/SVA.
In automatic start mode, the FADEC has the full authority on the control of the igniters, fuel, and SAV.
The EEC monitors the Exhaust Gas Temperature (EGT) and N2 according to their schedules to provide the correct fuel flow for a good acceleration.
When N2 reaches 55%, the EEC controls the igniter to OFF.
When N2 reaches 60%, the EEC controls the SAV to close.
The engine continues to accelerate and stabilizes at idle speed.
The usual standard parameters are:
- N1 = 19%,
- N2 = 60%,
- EGT = 440 ºC,
- FF = 500 LBS/h.

If the second engine has to be started, the ENG MODE rotary selector should stay on the IGN/START position.
This will avoid activating the continuous ignition on the running engine if the selector is cycled to NORM and again to IGN/START.
When both engines are running, the selector is set back to NORM, the WHEEL page will appear instead of the ENGINE page if at least one engine running.
Pilot initiated abortion:
On the ground or in flight, the automatic start sequence can be manually aborted by selecting the ENG MASTER lever to the OFF position.
This leads to:
- SAV closure,
- Igniter(s) off,
- FMV, LPSOV and HPSOV closure.

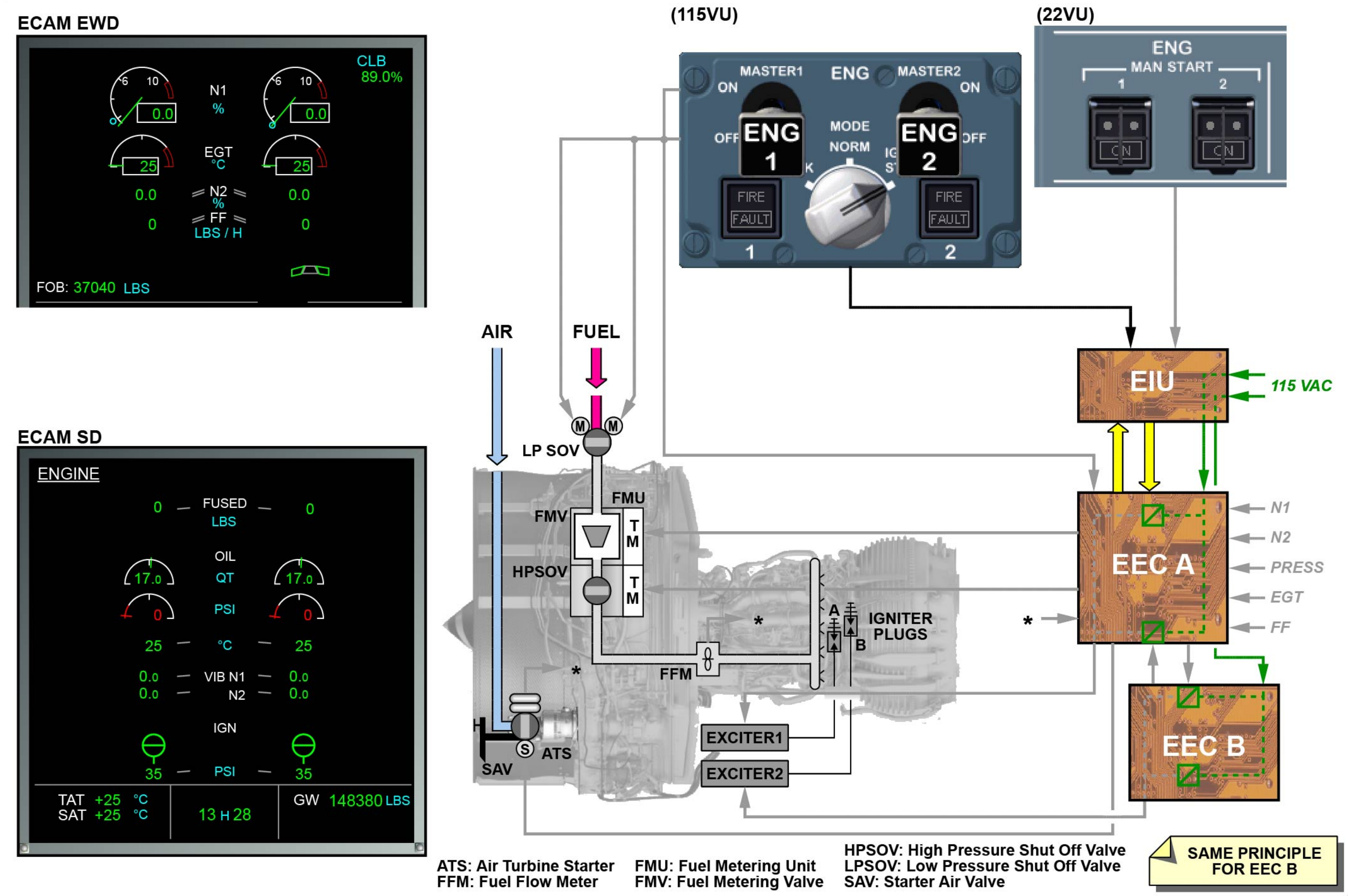
NOTE: EEC does not dry motor the engine when an automatic start is manually aborted.

Automatic protection:

On the ground, the EEC has the authority:

- to abort a start only in case of severe malfunction or
- to perform a maximum of three start attempts in case of minor fault. In this case, the EEC will abort the start, dry motor the engine and attempt a new start.

In flight, the EEC cannot abort a start but it can accommodate or provide fault annunciation.


ECAM EWD
CLB
89.0%
N1
%
6
10
0.0
EGT
°C
25
N2
%
FF
LBS / H
0.0
0
FOB: 37040 LBS
ECAM SD
ENGINE
FUSED
LBS
0
OIL
QT
17.0
PSI
0
°C
25
VIB N1
N2
0.0
IGN
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
ENG 2
MODE
NORM
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
AIR
FUEL
M
LP SOV
FMU
FMV
T M
HPSOV
FFM
A
B
IGNITER PLUGS
*
EXCITER1
EXCITER2
S
ATS
SAV
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B

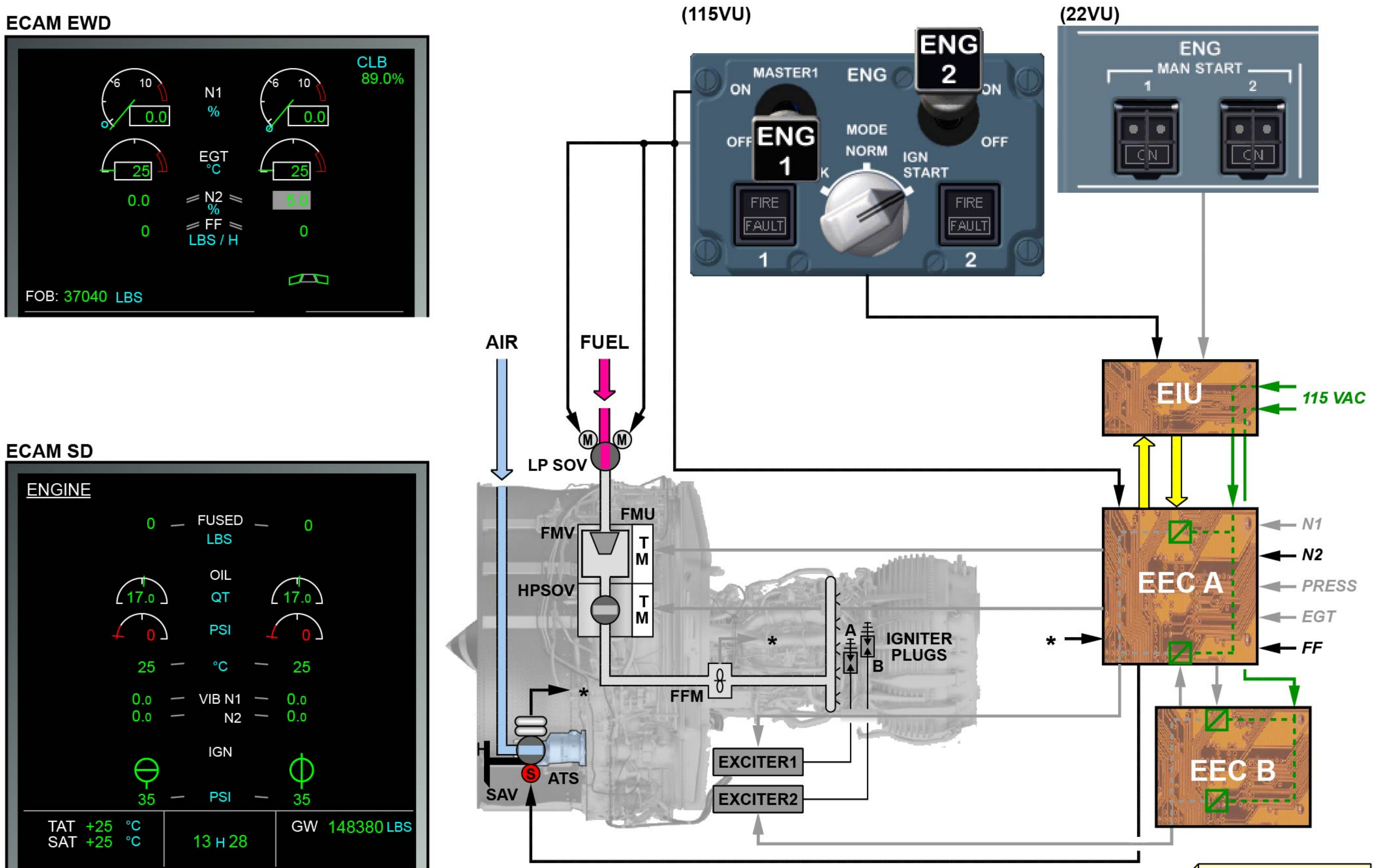
ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

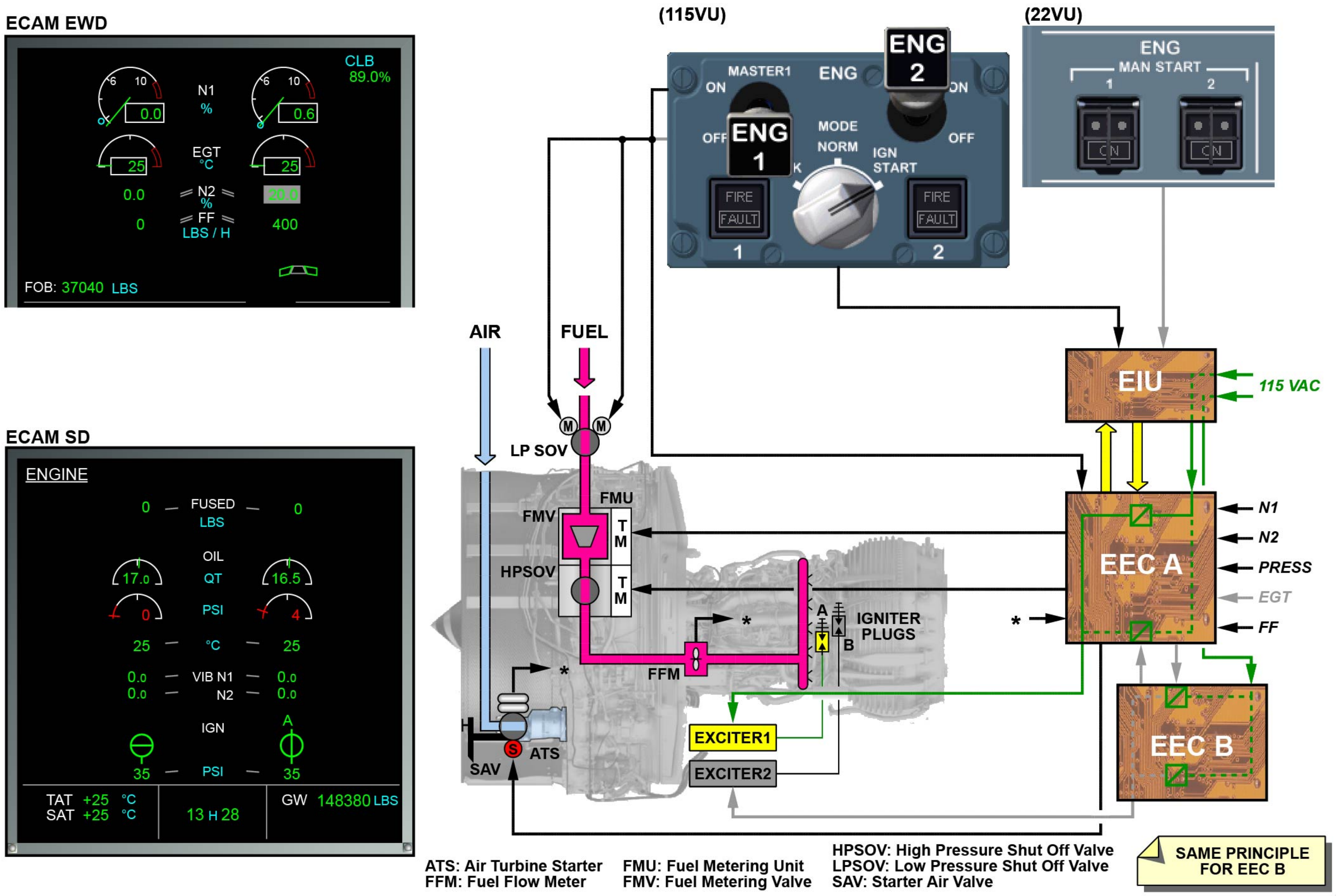
SAME PRINCIPLE FOR EEC B

AUTOMATIC START


ECAM EWD
CLB
89.0%
N1
%
0.0
0.0
EGT
°C
25
25
0.0
N2
%
FF
LBS / H
0
0
FOB: 37040 LBS
ECAM SD
ENGINE
0
FUSED
LBS
0
OIL
QT
17.0
17.0
PSI
0
0
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ON
OFF
ENG 1
ENG
ENG 2
ON
OFF
MODE
NORM
IGN START
FIRE FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
TM
HPSOV
TM
IGNITER PLUGS
A
B
FFM
ATS
SAV
S
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
*
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

AUTOMATIC START

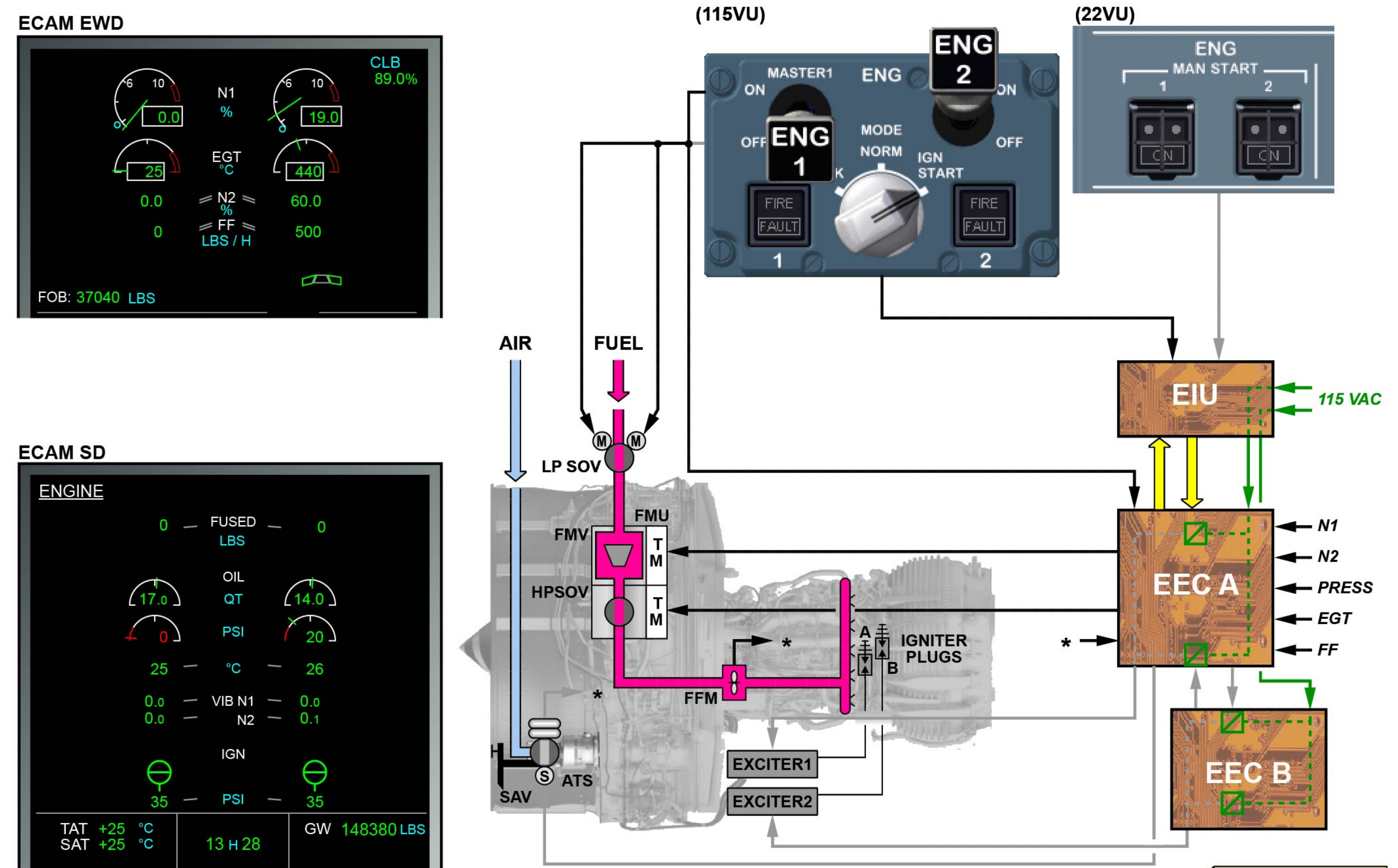

ECAM EWD
CLB
89.0%
6
10
0.0
N1
%
0.6
25
EGT
°C
25
0.0
N2
%
20.0
0
FF
LBS / H
400
FOB: 37040 LBS
ECAM SD
ENGINE
0
FUSED
LBS
0
OIL
17.0
QT
16.5
0
PSI
4
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
A
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
ENG 2
ON
ON
OFF
ENG 1
MODE
NORM
OFF
IGN START
FIRE
FAULT
1
FIRE
FAULT
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
LP SOV
M
M
FMU
FMV
T M
HPSOV
T M
*
FFM
A
B
IGNITER PLUGS
*
*
SAV
ATS
S
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

AUTOMATIC START


ECAM EWD
CLB
89.0%
6
10
0.0
N1
%
19.0
25
EGT
°C
440
0.0
N2
%
60.0
0
FF
LBS / H
500
FOB: 37040 LBS
ECAM SD
ENGINE
0
FUSED
LBS
0
OIL
QT
17.0
14.0
PSI
0
20
25
°C
26
0.0
VIB N1
0.0
0.0
N2
0.1
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
ON
ENG
2
ON
OFF
ENG
1
MODE
NORM
IGN
START
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
EIU
115 VAC
LP SOV
M
M
FMU
FMV
T
M
HPSOV
T
M
*
A
B
IGNITER
PLUGS
*
EEC A
N1
N2
PRESS
EGT
FF
*
FFM
ATS
S
SAV
H
EXCITER1
EXCITER2
EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

SAME PRINCIPLE FOR EEC B

AUTOMATIC START

IGNITION AND STARTING SYSTEM D/O (US)

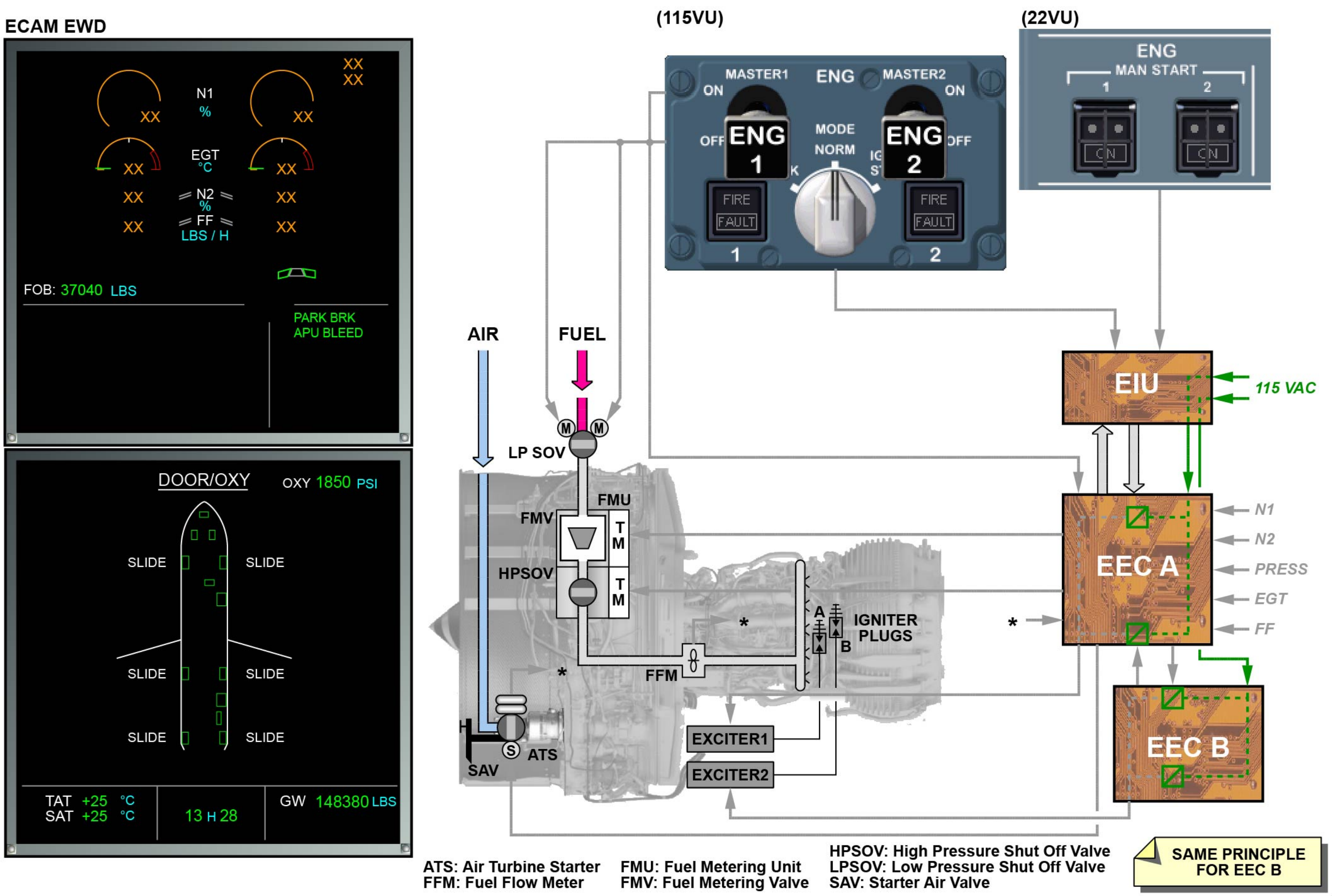
MANUAL START

A manual engine start procedure is included in the EECs engine starting logic for ground or flight condition.
In the manual start mode, engine starting control is under limited authority of the engaged EEC.
The SAV, fuel, and ignition are controlled from the cockpit via the EEC.
Bleed air source being available, a manual start sequence is commanded by first setting the rotary selector to the IGN/START position to power and signal the EEC.
The ENGINE page appears on the SD page of the ECAM.
The ENGINE page displays the IGN indication, SAV position and bleed pressure during this sequence.
At the same time, the APU bleed demand will increase and the pack valves will close.
The next action is to engage the ENG MAN START push-button to the ON position. This will lead the EEC to open the SAV.
When N2 is above the minimum fuel pressurization speed (on-ground approximately 20% N2), the ENG MASTER lever is set to the ON position. The EEC commands fuel flow and both igniters simultaneously.
The EEC monitors the EGT and N2 according to their schedules to provide the correct fuel flow but EGT limit protection is inactive.
When N2 reaches 55% N2, the EEC de-energizes the ignition system.
At 60%, the SAV will be controlled to close.
The engine continues to accelerate and stabilizes at idle speed.
Pilot initiated abortion:
When a manual engine start has been initiated on ground or in flight, it shall be interrupted by either:
- de-selecting the ENG MAN START push-button before the ENG MASTER lever is commanded ON, or
- selecting ENG MASTER lever back to OFF position after it has already been selected ON.

Interruption of a manual start shall result in the following EEC commands:
- SAV closure,
- igniters off,
- FMV and HP fuel shut-off valve closure.

Automatic protection:
On the ground, the EEC has the authority
- to abort a start only in case of severe malfunction or
- to perform a maximum of three start attempts in case of minor fault. In this case, the EEC will abort the start, dry motor the engine and attempt a new start.

In flight, the EEC cannot abort a start but it can accommodate or provide fault annunciation.

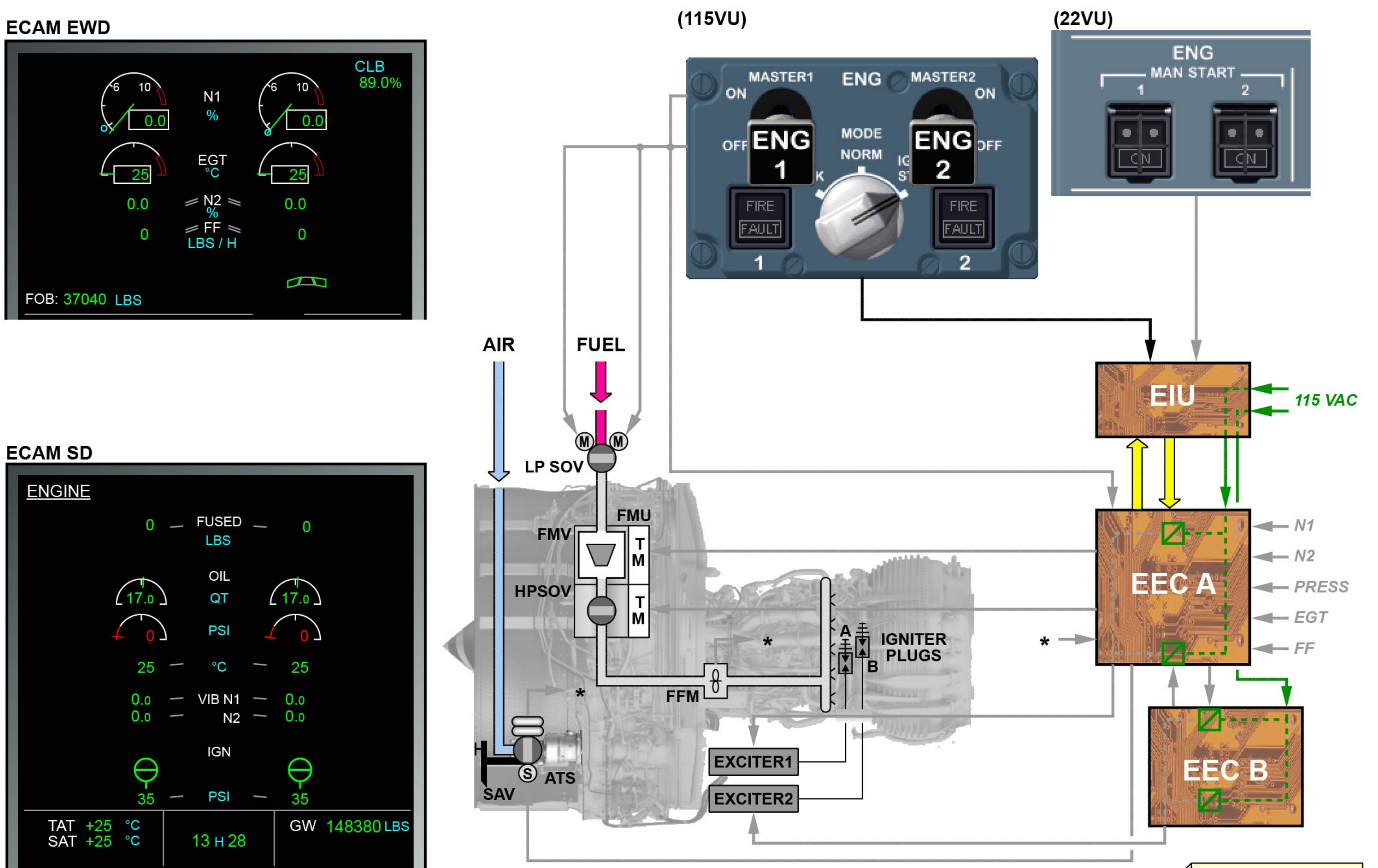

ECAM EWD
N1
%
XX
EGT
°C
N2
%
FF
LBS / H
FOB: 37040 LBS
PARK BRK
APU BLEED
DOOR/OXY
OXY 1850 PSI
SLIDE
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
ENG 2
MODE
NORM
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
AIR
FUEL
M
LP SOV
FMU
FMV
HPSOV
T
M
FFM
IGNITER PLUGS
A
B
EXCITER1
EXCITER2
SAV
S
ATS
*
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

MANUAL START


ECAM EWD
CLB
89.0%
N1
%
0.0
0.0
EGT
°C
25
25
N2
%
0.0
0.0
FF
LBS / H
0
0
FOB: 37040 LBS
ECAM SD
ENGINE
FUSED
LBS
0
0
OIL
QT
17.0
17.0
PSI
0
0
°C
25
25
VIB N1
N2
0.0
0.0
0.0
0.0
IGN
PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
ENG 2
MODE
NORM
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
AIR
FUEL
LP SOV
FMU
FMV
HPSOV
T M
FFM
SAV
ATS
S
M
IGNITER PLUGS
A
B
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
EEC B
N1
N2
PRESS
EGT
FF
*

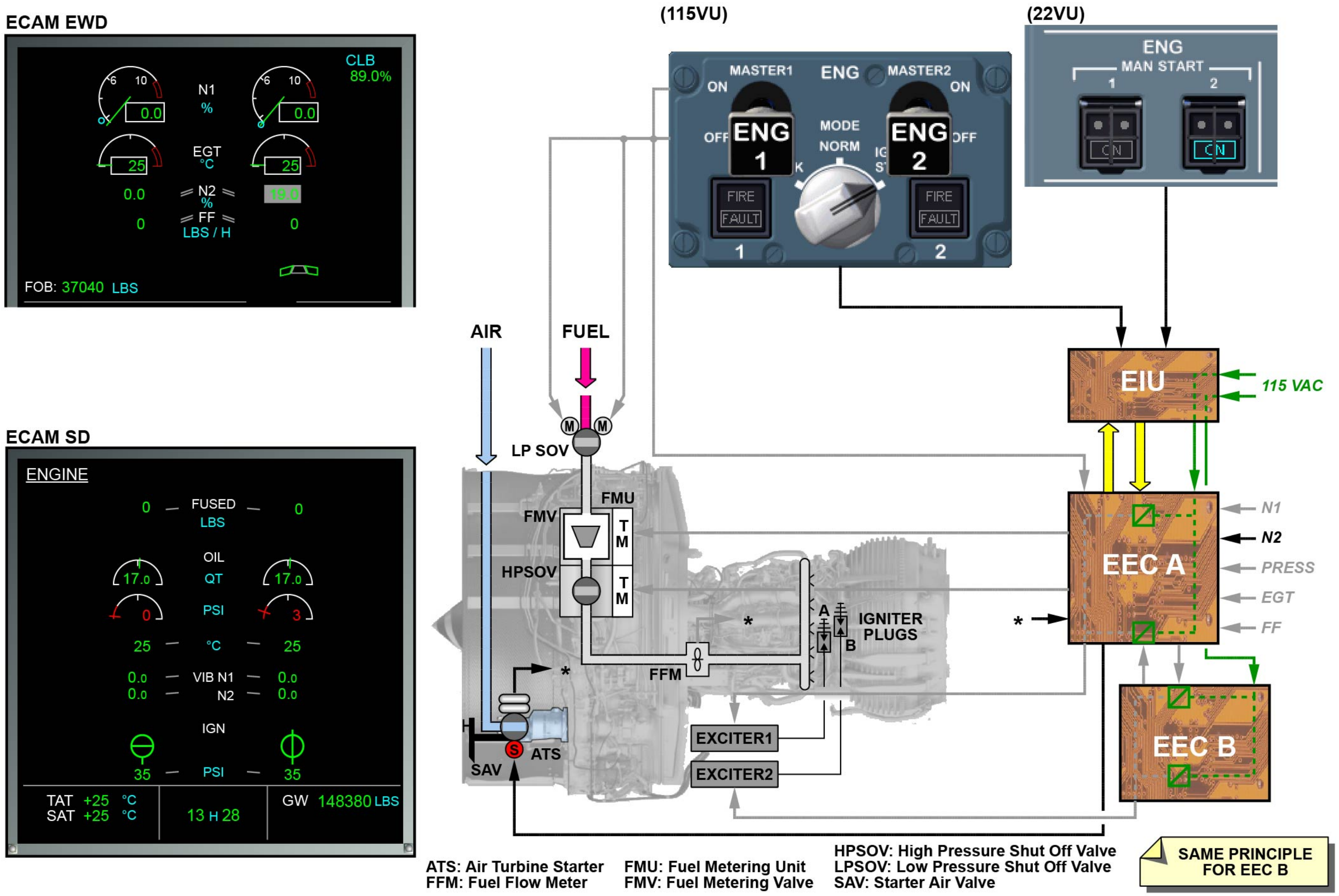
ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

SAME PRINCIPLE FOR EEC B

MANUAL START

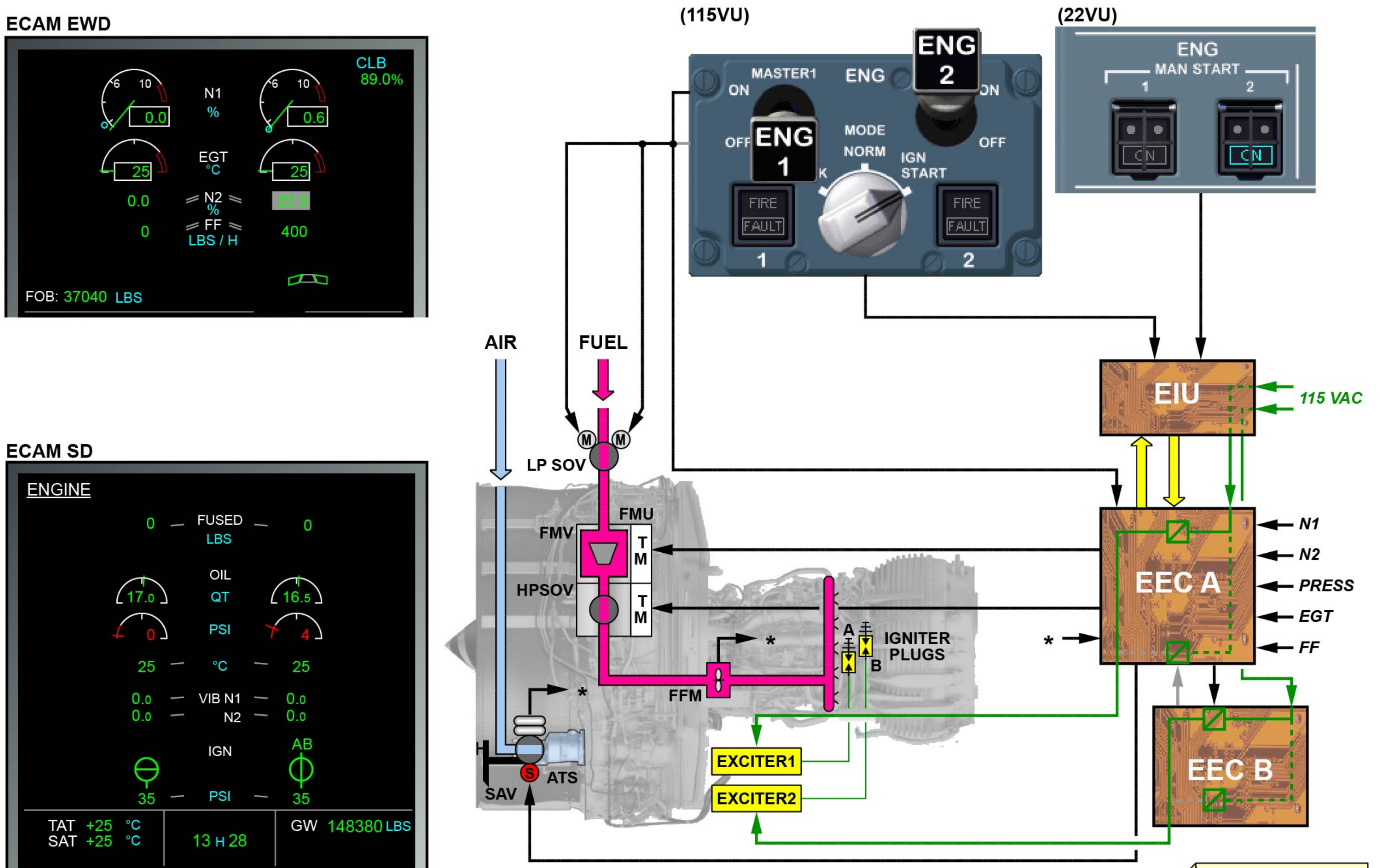

ECAM EWD
CLB 89.0%
N1 %
0.0
0.0
EGT °C
25
25
N2 %
0.0
19.0
FF LBS / H
0
0
FOB: 37040 LBS
ECAM SD
ENGINE
FUSED LBS
0
0
OIL
QT
17.0
17.0
PSI
0
3
°C
25
25
VIB N1
N2
0.0
0.0
0.0
0.0
IGN
PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
MASTER2
ON
OFF
ENG 1
MODE
NORM
ENG 2
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T M
HPSOV
T M
*
FFM
A
B
IGNITER PLUGS
*
H
S
ATS
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

MANUAL START


ECAM EWD
CLB
89.0%
N1
%
0.0
0.6
EGT
°C
25
25
0.0
N2
%
22.0
0
FF
LBS / H
400
FOB: 37040 LBS
ECAM SD
ENGINE
0
FUSED
LBS
0
OIL
QT
17.0
16.5
PSI
0
4
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
AB
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
ENG
2
ON
ON
OFF
ENG
1
OFF
MODE
NORM
IGN
START
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T
M
HPSOV
T
M
FFM
A
B
IGNITER
PLUGS
*
*
*
ATS
S
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
SAME PRINCIPLE
FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

MANUAL START

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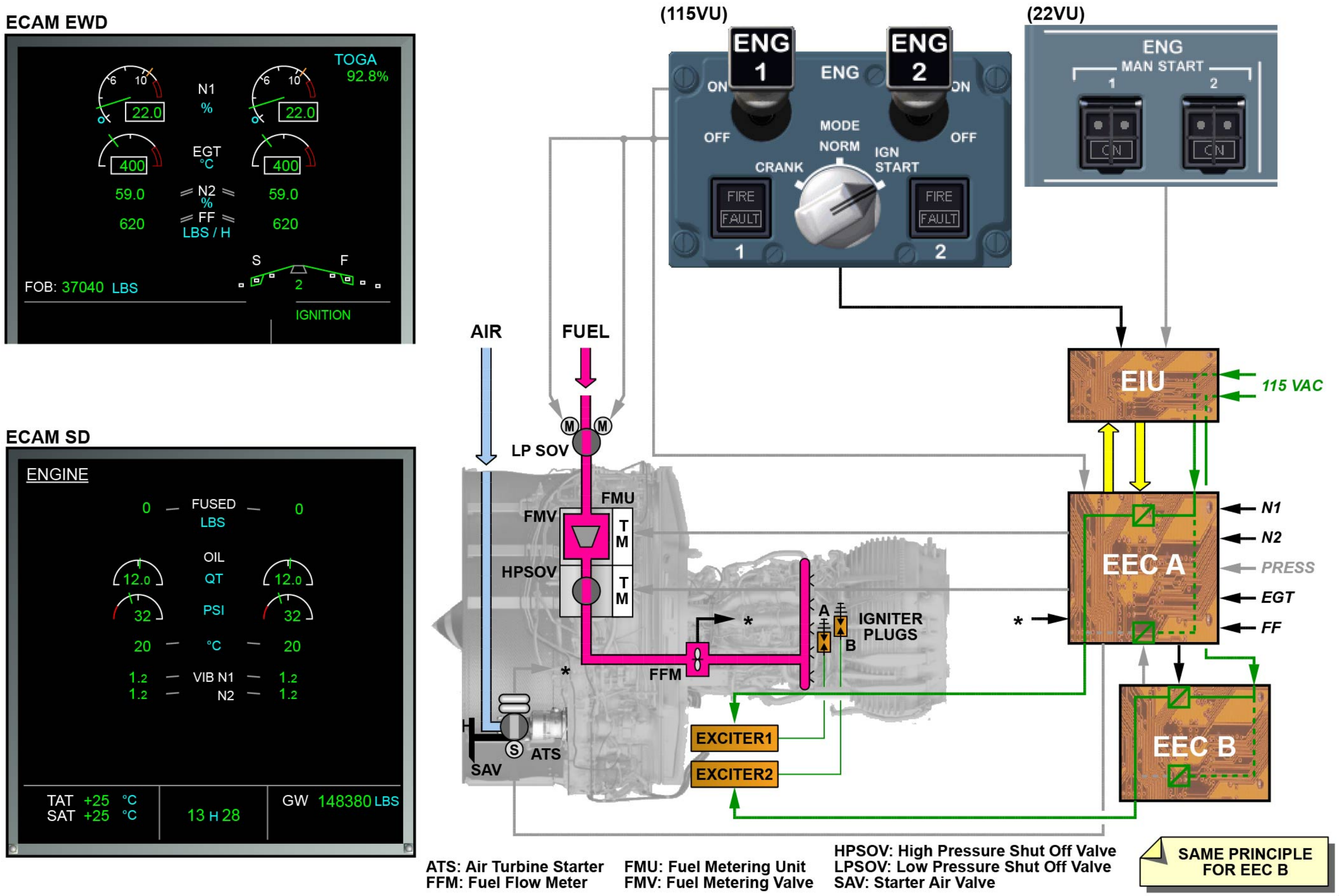
IGNITION AND STARTING SYSTEM D/O (US)

CONTINUOUS IGNITION

Continuous ignition is manually selected or automatically controlled by the FADEC.
During continuous ignition both igniters are active.
Manual command:
Once the engine is running above idle, the pilot can manually command continuous ignition at any time by moving the rotary selector to the IGN/START position.
Following a ground start, the rotary selector must be moved back to NORM before continuous ignition can be manually selected by moving it back to IGN/START position.
Continuous ignition shall remain commanded by the EEC until the rotary selector is moved back to NORM or until the combustor pressure (PS3) is greater than or equal to 175 psia.
Automatic command:
The EEC automatically commands continuous ignition when an engine flameout is detected in flight and PS3 is less than 175 psia even if the rotary selector is not set to the IGN/START position.


ECAM EWD
TOGA
92.8%
N1
%
22.0
22.0
EGT
°C
400
400
59.0
N2
%
59.0
620
FF
LBS / H
620
FOB: 37040 LBS
S
F
2
IGNITION
ECAM SD
ENGINE
0
FUSED
LBS
0
OIL
QT
12.0
12.0
PSI
32
32
20
°C
20
1.2
VIB N1
1.2
1.2
N2
1.2
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
ENG 1
ENG
ENG 2
ON
ON
OFF
OFF
MODE
NORM
CRANK
IGN START
FIRE FAULT
1
FIRE FAULT
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
TM
HPSOV
TM
*
FFM
*
A
B
IGNITER PLUGS
ATS
S
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B
SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

CONTINUOUS IGNITION

IGNITION AND STARTING SYSTEM D/O (US)

ENGINE CRANK

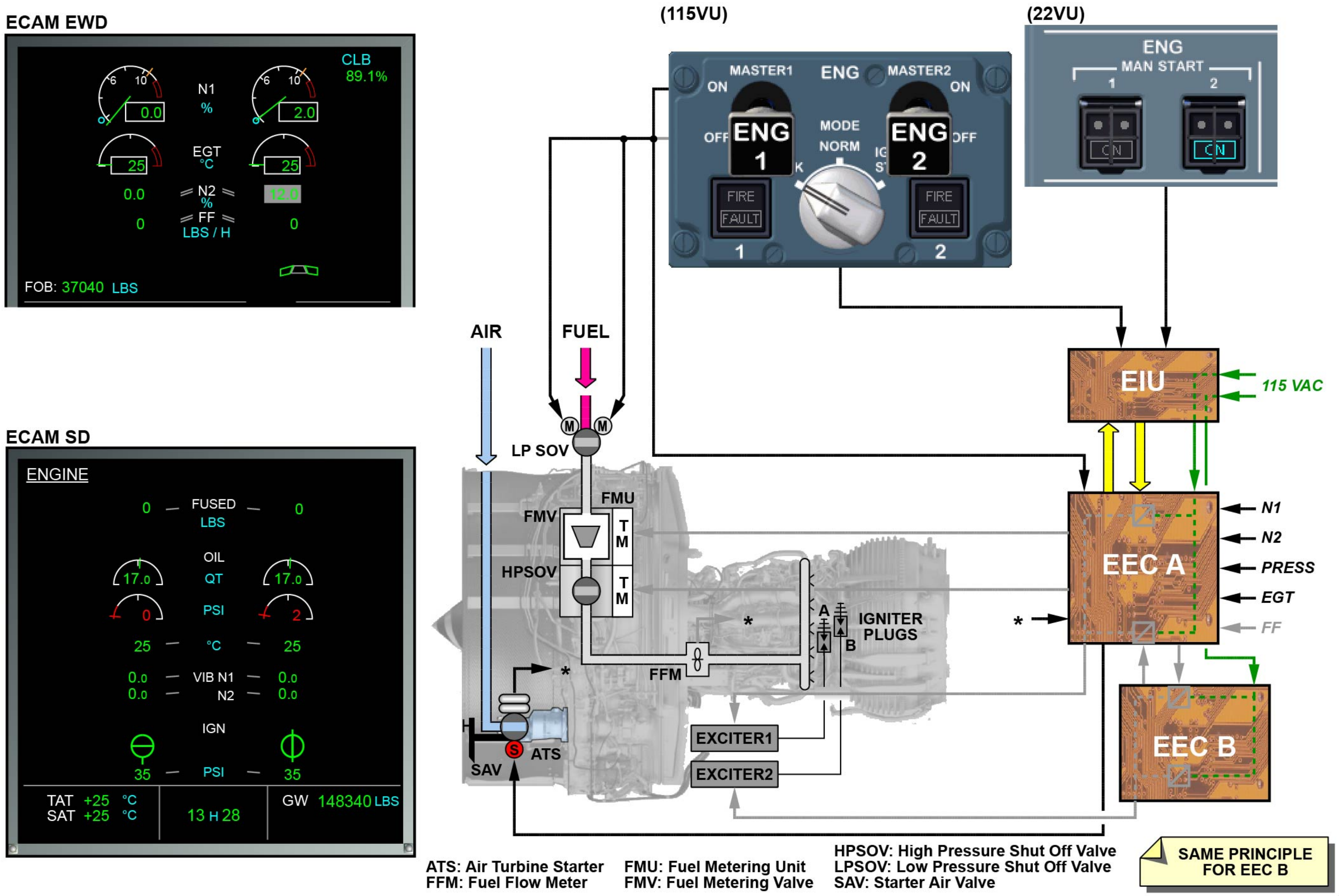
DRY CRANK

Cranking function is used to motor the engine on the ground for a short time with the use of the starter.
There are two cranking modes:
- dry cranking,
- wet cranking.

The dry cranking procedure is used to motor the engine to remove unburned fuel from the combustion chamber or cool down the engine or for some fuel or oil leak tests.
The EEC shall enter the engine dry crank sequence when all of the following conditions are true:
- the engine is not running and,
- the aircraft is on ground and,
- the rotary selector is set to CRANK.

This will power up the EECs and isolate both ignition systems.
The ENGINE page appears automatically on the ECAM SD.
When the ENG MAN START P/B is set to ON, the EEC commands the SAV to open.
The dry motoring can be interrupted at any time by pushing the ENG MAN START pushbutton to OFF or positioning the ENG MODE rotary selector to NORM position.
The usual starter duty cycle is 3 starter crank cycles or 5 minutes maximum of continuous cranking. A 30 minutes cool down period is necessary for additional use.

WARNING: the EEC is able to initiate a start sequence immediately following a dry motoring sequence by setting the ENG MODE rotary selector to IGN/START position and the ENG MASTER control lever to ON position.


ECAM EWD
CLB
89.1%
N1
%
0.0
2.0
EGT
°C
25
25
N2
%
0.0
12.0
FF
LBS / H
0
0
FOB: 37040 LBS
ECAM SD
ENGINE
FUSED
LBS
0
0
OIL
QT
17.0
17.0
PSI
0
2
°C
25
25
VIB N1
N2
0.0
0.0
0.0
0.0
IGN
PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148340 LBS
(115VU)
MASTER1
ENG
MASTER2
ON
ON
OFF
OFF
ENG 1
ENG 2
MODE
NORM
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
HPSOV
T
M
T
M
*
A
B
IGNITER
PLUGS
FFM
*
SAV
S
ATS
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B
SAME PRINCIPLE
FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

ENGINE CRANK - DRY CRANK

IGNITION AND STARTING SYSTEM D/O (US)

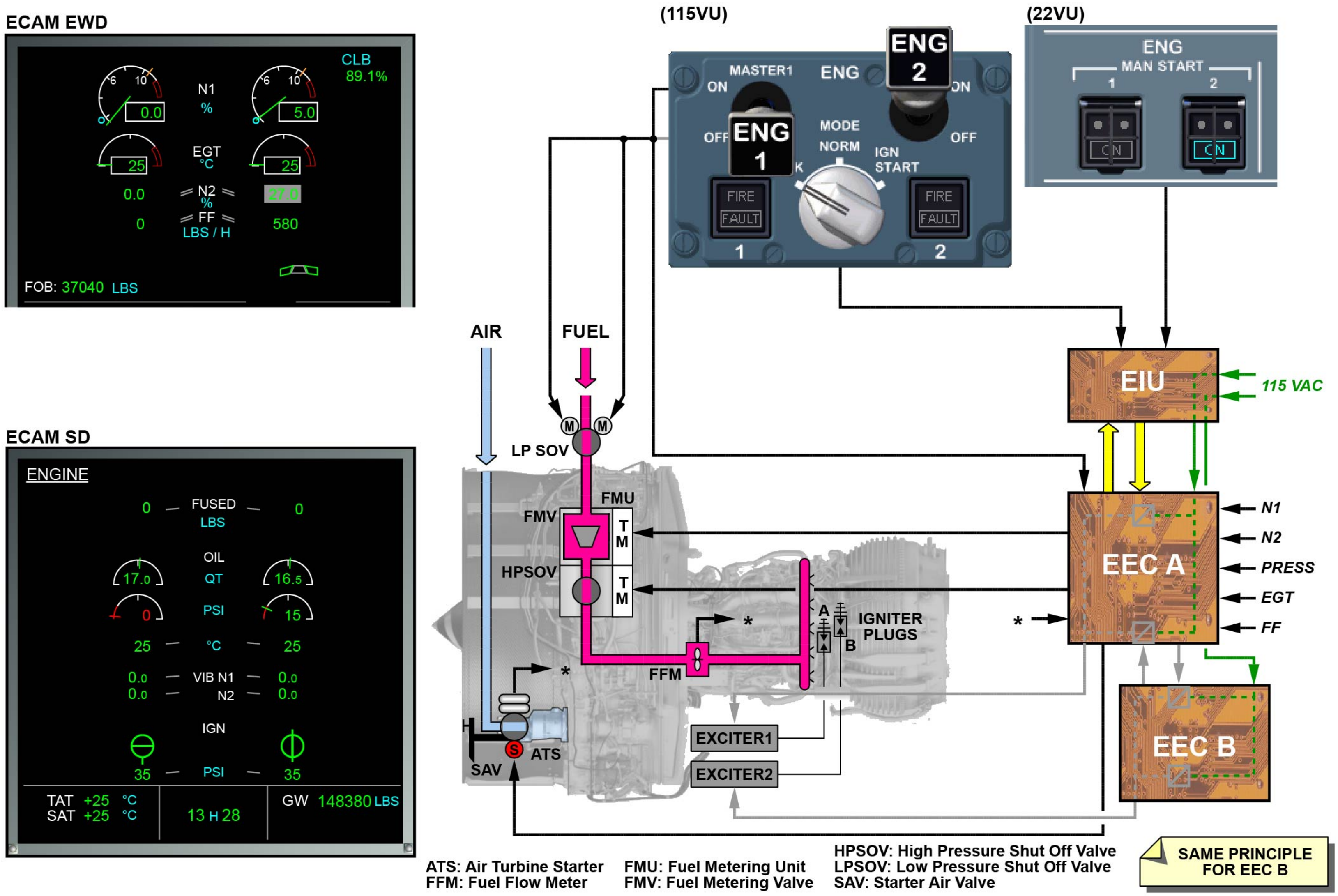
ENGINE CRANK (continued)

WET CRANK

The wet cranking procedure is used to motor the engine for specific fuel leak tests.
The fuel flow is commanded but both ignition systems are isolated.
The fuel goes through the FMU and the SCU/SVA to the actuator fuel pressure lines, the engine fuel manifolds (primary fuel lines only), and nozzles. Fuel is then sprayed in the combustion chamber.
The first steps of the wet crank sequence are the same as the ones for the dry crank:

- the engine is not running,
- the aircraft is on ground,
- the rotary selector is set to CRANK (EECs powered, both ignition systems isolated, ENGINE page appears),
- the ENG MAN START P/B is set to ON (SAV opening).

When N2 speed stabilizes, the ENG MASTER lever is set to the ON position to command the fuel flow.
After 15 seconds, the ENG MASTER lever is set to the OFF position to cut the fuel supply.
The SAV command is maintained 30 seconds to blow all the fuel from the engine.
The wet motoring ends by pushing the ENG MAN START pushbutton to OFF or/and positioning the ENG MODE rotary selector to NORM position.


ECAM EWD
CLB
89.1%
N1
%
0.0
5.0
EGT
°C
25
25
N2
%
0.0
27.0
FF
LBS / H
0
580
FOB: 37040 LBS
ECAM SD
ENGINE
FUSED
LBS
0
0
OIL
QT
17.0
16.5
PSI
0
15
°C
25
25
VIB N1
N2
0.0
0.0
0.0
0.0
IGN
PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN
START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
AIR
FUEL
LP SOV
FMU
FMV
HPSOV
T
M
FFM
ATS
SAV
IGNITER PLUGS
A
B
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
EEC B
N1
N2
PRESS
EGT
FF
*
SAME PRINCIPLE FOR EEC B

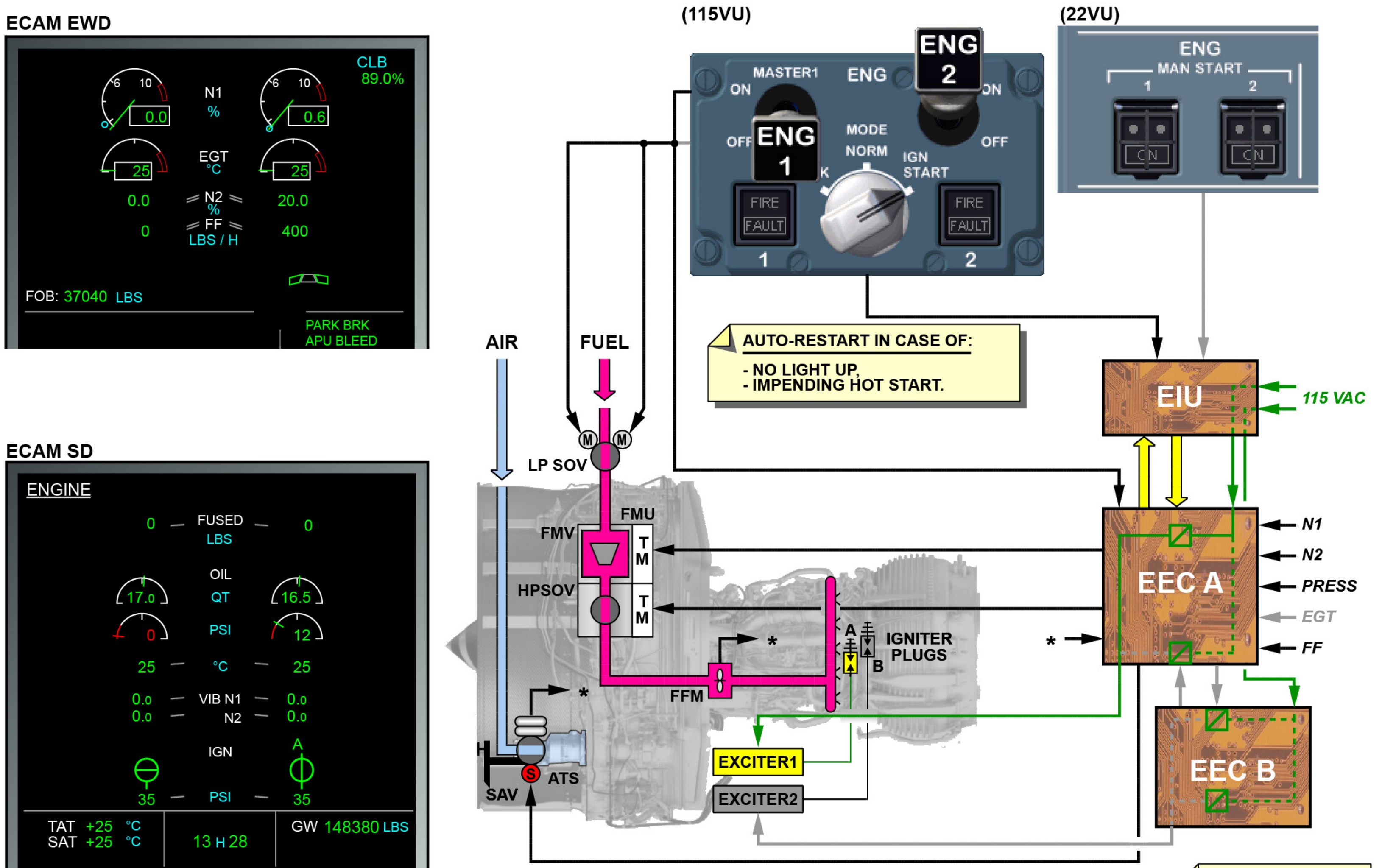
ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

ENGINE CRANK - WET CRANK

LEAP START FAILURES DESCRIPTION AND OPERATION (US)

AUTO-RESTART

The Electronic Engine Controls (EECs) abort the automatic start, dry motor the engine and attempt an auto-restart for the following reasons:
- No light up (Exhaust Gas Temperature (EGT) low),
- Impending Hot Start (EGT reaches starting limit).


ECAM EWD
CLB
89.0%
N1
%
0.0
0.6
EGT
°C
25
25
N2
%
0.0
20.0
FF
LBS / H
0
400
FOB: 37040 LBS
PARK BRK
APU BLEED
ECAM SD
ENGINE
FUSED
LBS
0
0
OIL
QT
17.0
16.5
PSI
0
12
°C
25
25
VIB N1
N2
0.0
0.0
0.0
0.0
IGN
A
PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN START
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
AIR
FUEL
LP SOV
FMU
FMV
HPSOV
T M
FFM
A
B
IGNITER PLUGS
*
SAV
ATS
S
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
EEC B
N1
N2
PRESS
EGT
FF

AUTO-RESTART IN CASE OF:

- NO LIGHT UP,
- IMPENDING HOT START.

SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

AUTO-RESTART

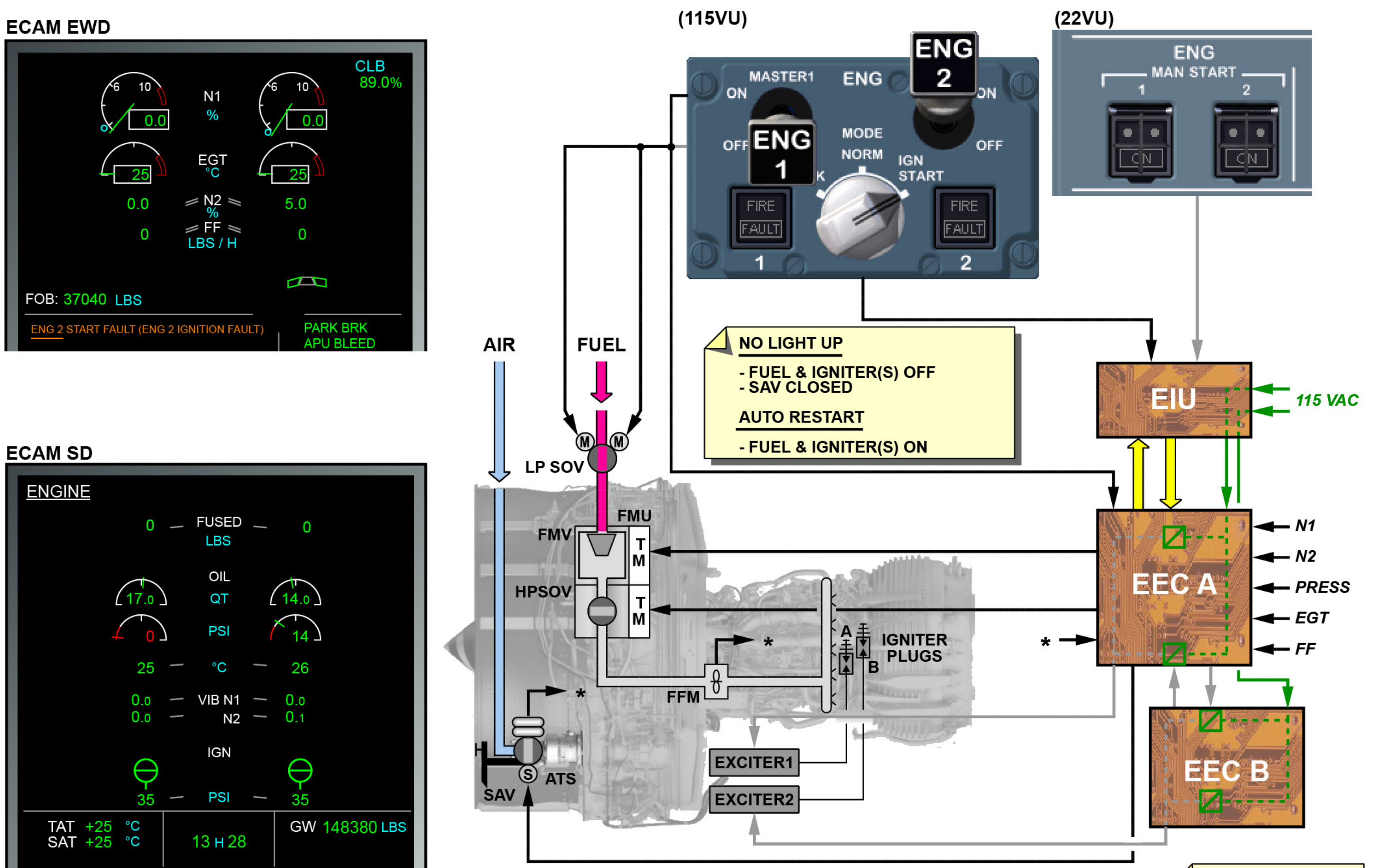
LEAP START FAILURES DESCRIPTION AND OPERATION (US)

NO LIGHT UP

The active EEC detects and accommodates the No Light Up conditions (failure to light) during all automatic engine starts.
The EEC does not accommodate No Light Up conditions during manual starts.
The EEC accommodation for a ground auto start No Light Up condition is performed by the following actions:
- Interrupt fuel flow and ignition,
- Increment the sub idle fuel flow schedule,
- Motor the engine for 30 seconds,
- Restart with same igniter.

The EEC accommodation for a second ground auto start No Light Up condition is performed by the following actions:
- Interrupt fuel flow and ignition,
- Increment the sub idle fuel flow schedule,
- Motor the engine for 30 seconds,
- Restart with dual ignition.

If this auto-restart attempt fails, the start is aborted and the EEC generates the ECAM alert "ENG X START FAULT - ENG X IGNITION FAULT".


ECAM EWD
N1 %
0.0
0.0
CLB
89.0%
EGT °C
25
25
N2 %
0.0
5.0
FF LBS / H
0
0
FOB: 37040 LBS
ENG 2 START FAULT (ENG 2 IGNITION FAULT)
PARK BRK
APU BLEED
ECAM SD
ENGINE
FUSED LBS
0
0
OIL QT
17.0
14.0
PSI
0
14
°C
25
26
VIB N1
0.0
0.0
N2
0.0
0.1
IGN PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
ENG 2
ON
OFF
ENG 1
MODE
NORM
IGN START
FIRE FAULT
1
2
(22VU)
ENG MAN START
1
2
ON
AIR
FUEL
LP SOV
FMU
FMV
HPSOV
TM
TM
FFM
IGNITER PLUGS
A
B
EXCITER1
EXCITER2
ATS
SAV
EIU
115 VAC
EEC A
EEC B
N1
N2
PRESS
EGT
FF
*

NO LIGHT UP
- FUEL & IGNITER(S) OFF
- SAV CLOSED

AUTO RESTART
- FUEL & IGNITER(S) ON

SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

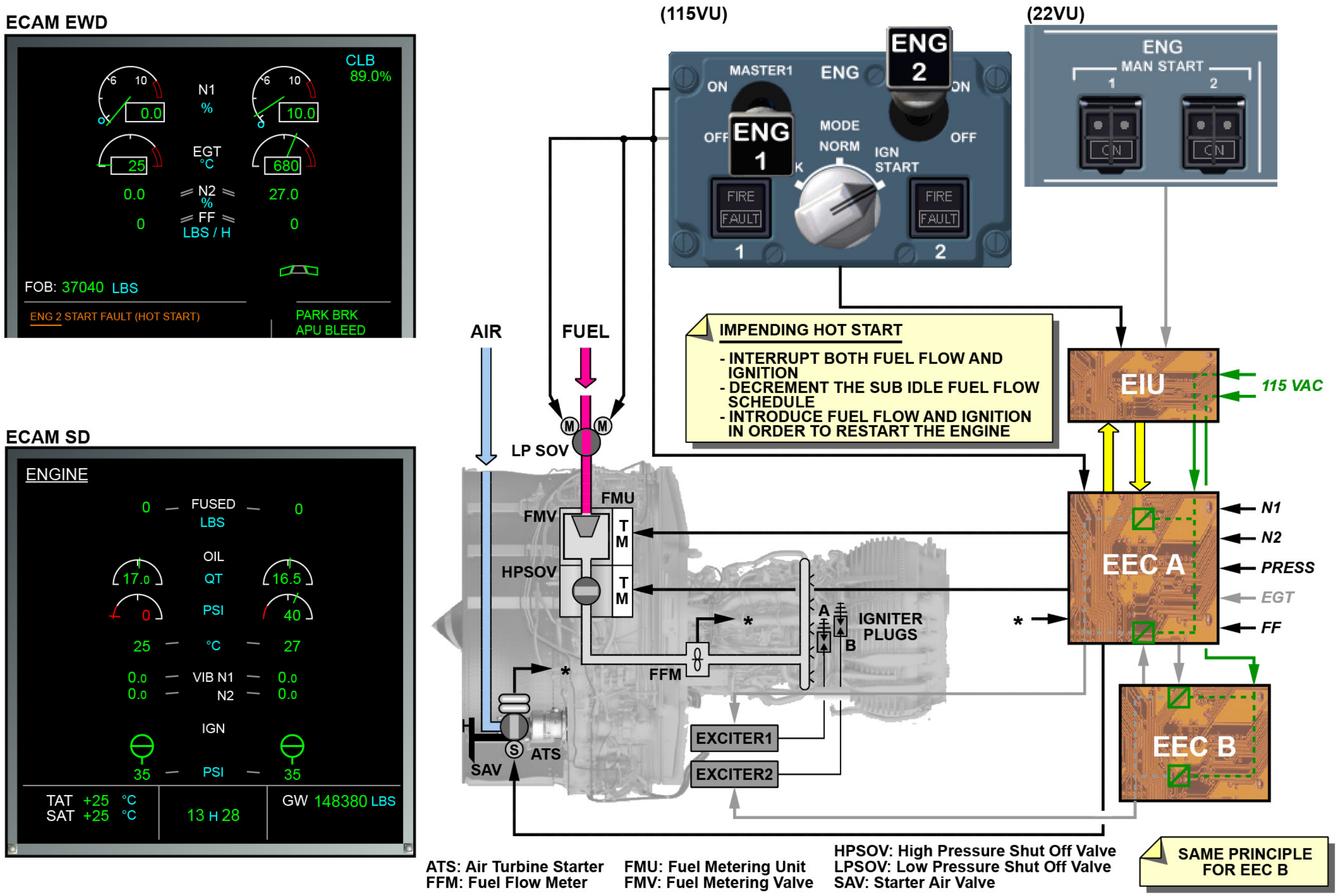
NO LIGHT UP

LEAP START FAILURES DESCRIPTION AND OPERATION (US)

IMPENDING HOT START

The active EEC detects and accommodates Impending Hot Start conditions during starting and rollback when the EGT is within 10 degrees Celsius of the EGT Start Limit. The EGT Start Limit is 750 degrees Celsius during ground starts.
The EEC accommodation for a Hot Start is performed by the following actions order:
- Interrupt both fuel flow and ignition for 1 second,
- Decrement the sub idle fuel flow schedule,
- Introduce fuel flow and ignition in order to restart the engine.

The EEC shall dry crank the engine during Hot Start accommodation if a stall is detected during a ground auto start, a starter assisted in flight start, or a manual start.
If this auto-restart attempt fails, the start is aborted and the EEC generates the ECAM alert "ENG x START FAULT- HOT START".


ECAM EWD
N1 %
6 10 0.0
6 10 10.0
CLB 89.0%
EGT °C
25
680
N2 %
0.0
27.0
FF LBS / H
0
0
FOB: 37040 LBS
ENG 2 START FAULT (HOT START)
PARK BRK
APU BLEED
ECAM SD
ENGINE
FUSED LBS
0
0
OIL QT
17.0
16.5
PSI
0
40
°C
25
27
VIB N1 N2
0.0
0.0
0.0
0.0
IGN PSI
35
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
ON
OFF
ENG 1
ENG 2
MODE
NORM
IGN START
FIRE FAULT
1
2
(22VU)
ENG MAN START
1
2
ON
AIR
FUEL
LP SOV
FMV
FMU
HPSOV
T M
T M
FFM
IGNITER PLUGS
A
B
EXCITER1
EXCITER2
ATS
SAV
S
M
EIU
115 VAC
EEC A
EEC B
N1
N2
PRESS
EGT
FF
*
SAME PRINCIPLE FOR EEC B

IMPENDING HOT START

- INTERRUPT BOTH FUEL FLOW AND IGNITION
- DECREMENT THE SUB IDLE FUEL FLOW SCHEDULE
- INTRODUCE FUEL FLOW AND IGNITION IN ORDER TO RESTART THE ENGINE

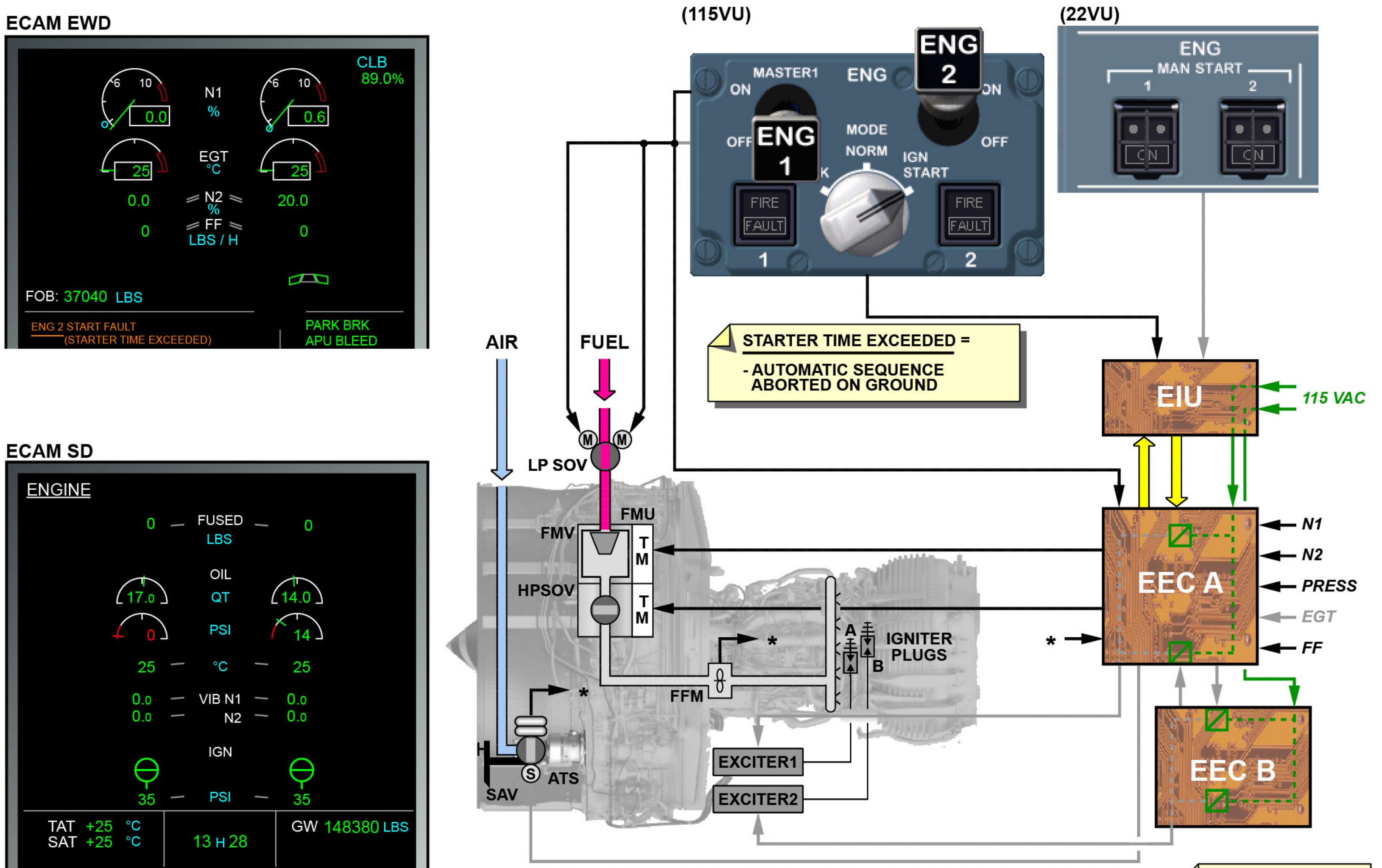
ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

IMPENDING HOT START

LEAP START FAILURES DESCRIPTION AND OPERATION (US)

STARTER TIME EXCEEDED

The active EEC detects Starter Duty Cycle exceedances when the SAV is open and sufficient pressure exists to drive the pneumatic starter for more than 5 minutes.
A Starter Duty Cycle exceedance during a ground auto start or a ground crank procedure aborts the start procedure.
The EEC identifies an excessive starter duty and generates the ECAM alert "ENG x START FAULT - STARTER TIME EXCEEDED".
In the other cases (ground man start, in flight auto and man starts), the EECs will only generates the ECAM alert.


ECAM EWD
CLB
89.0%
6
10
0.0
N1
%
0.6
25
EGT
°C
25
0.0
N2
%
20.0
0
FF
LBS / H
0
FOB: 37040 LBS
ENG 2 START FAULT
(STARTER TIME EXCEEDED)
PARK BRK
APU BLEED
ECAM SD
ENGINE
0
FUSED
LBS
0
OIL
17.0
QT
14.0
0
PSI
14
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 148380 LBS
(115VU)
MASTER1
ENG
ENG 2
ON
OFF
ENG 1
MODE
NORM
IGN START
OFF
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T M
HPSOV
T M
*
IGNITER PLUGS
A
B
FFM
*
ATS
S
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B

STARTER TIME EXCEEDED =

- AUTOMATIC SEQUENCE ABORTED ON GROUND

SAME PRINCIPLE FOR EEC B

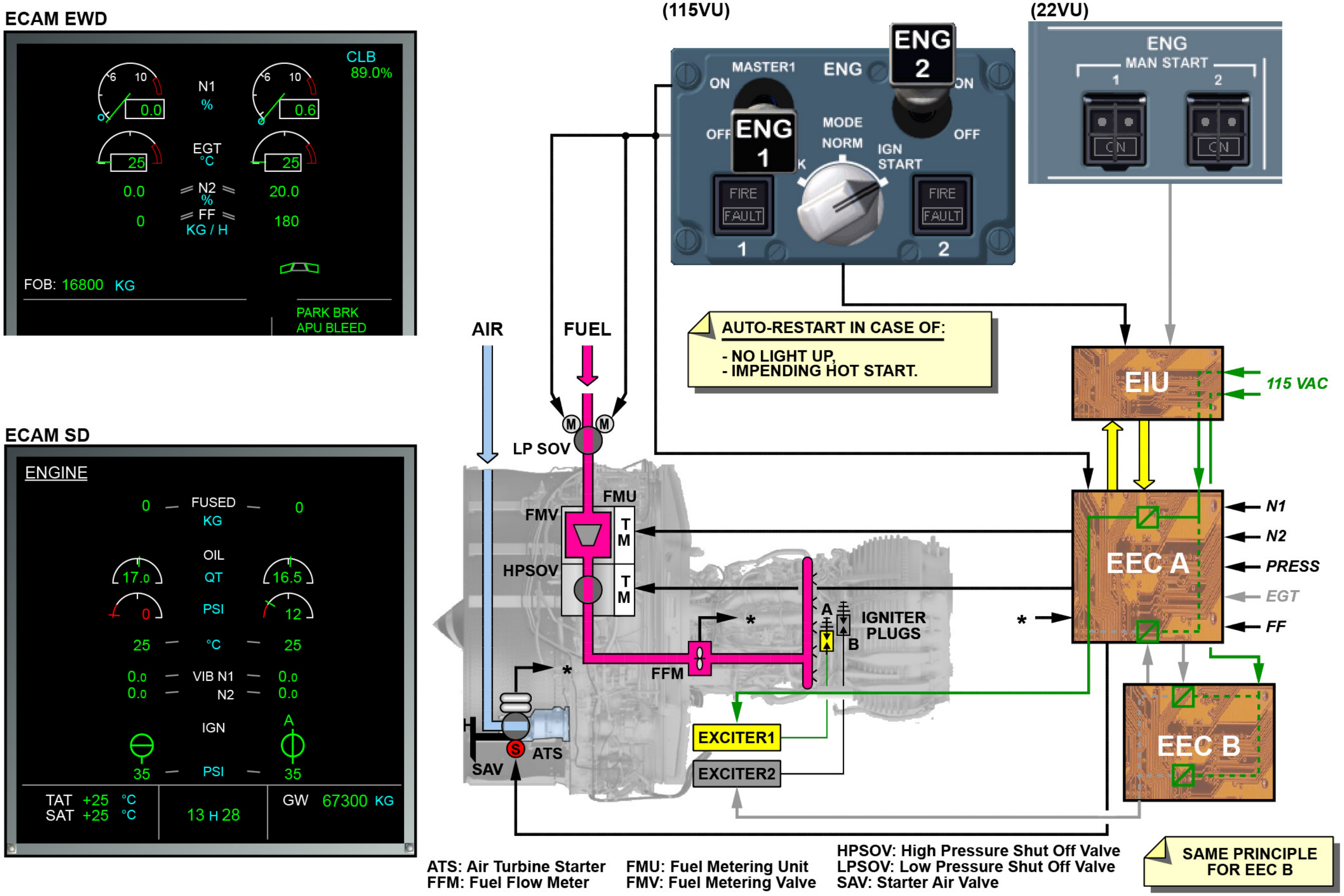
ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

STARTER TIME EXCEEDED

LEAP START FAILURES DESCRIPTION AND OPERATION (ME)

AUTO-RESTART

The Electronic Engine Controls (EECs) abort the automatic start, dry motor the engine and attempt an auto-restart for the following reasons:
- No light up (Exhaust Gas Temperature (EGT) low),
- Impending Hot Start (EGT reaches starting limit).


ECAM EWD
CLB
89.0%
6
10
0.0
0.6
N1
%
EGT
°C
25
25
0.0
N2
%
20.0
0
FF
KG / H
180
FOB: 16800 KG
PARK BRK
APU BLEED
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
16.5
PSI
0
12
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
A
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
ENG 2
MASTER1
ENG
ON
OFF
ENG 1
MODE
NORM
IGN
START
OFF
FIRE
FAULT
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
ON
AIR
FUEL
M
M
LP SOV
FMU
FMV
T
M
HPSOV
T
M
FFM
ATS
SAV
S
*
*
A
B
IGNITER
PLUGS
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
*
EEC B

AUTO-RESTART IN CASE OF:
- NO LIGHT UP,
- IMPENDING HOT START.

SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter

FMU: Fuel Metering Unit
FMV: Fuel Metering Valve

HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

AUTO-RESTART

LEAP START FAILURES DESCRIPTION AND OPERATION (ME)

NO LIGHT UP

The active EEC detects and accommodates the No Light Up conditions (failure to light) during all automatic engine starts.
The EEC does not accommodate No Light Up conditions during manual starts.
The EEC accommodation for a ground auto start No Light Up condition is performed by the following actions:

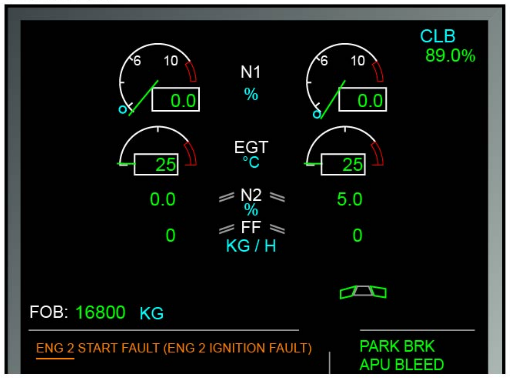
- Interrupt fuel flow and ignition,
- Increment the sub idle fuel flow schedule,
- Motor the engine for 30 seconds,
- Restart with same igniter.

The EEC accommodation for a second ground auto start No Light Up condition is performed by the following actions:

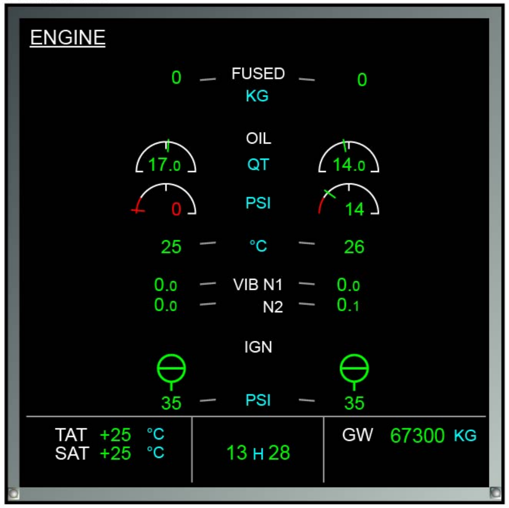
- Interrupt fuel flow and ignition,
- Increment the sub idle fuel flow schedule,
- Motor the engine for 30 seconds,
- Restart with dual ignition.

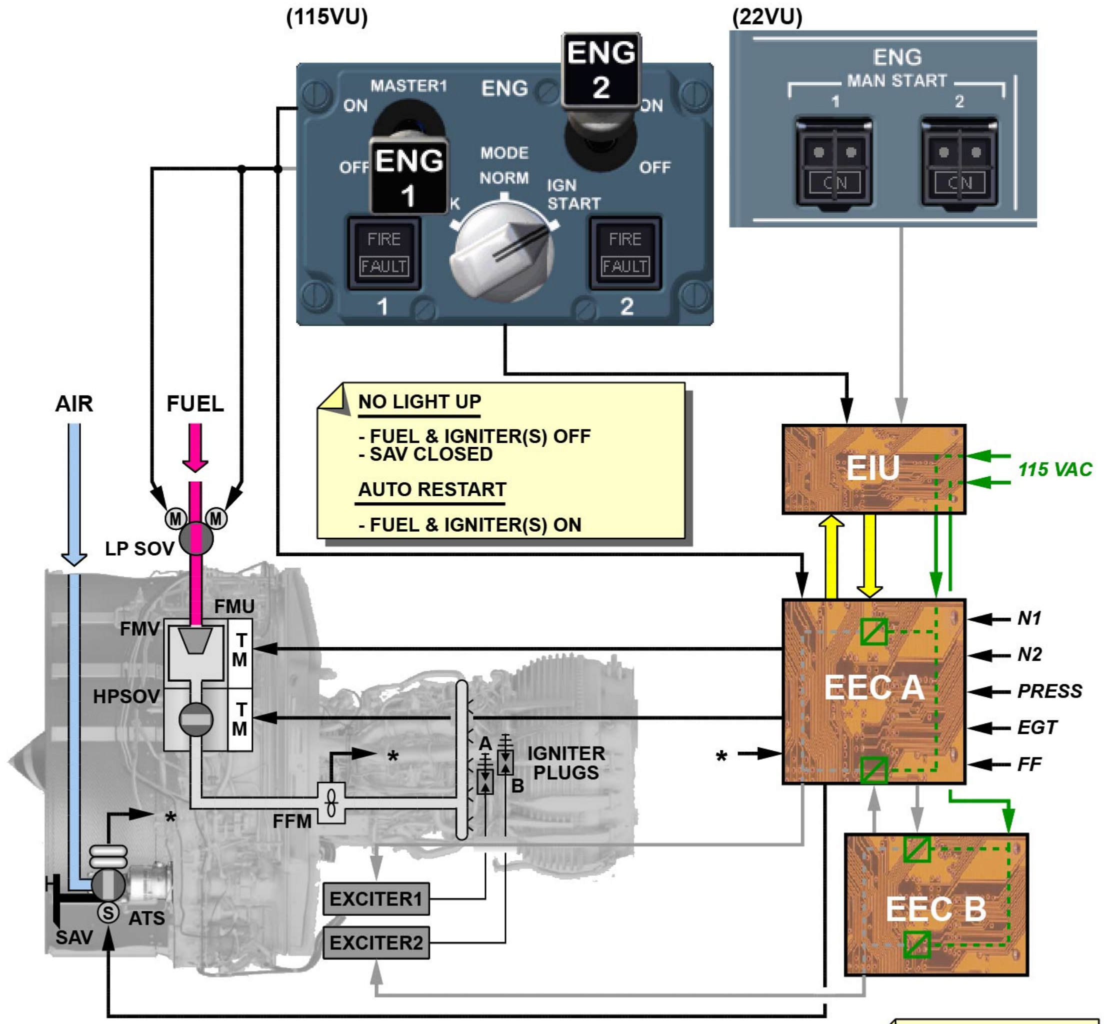
If this auto-restart attempt fails, the start is aborted and the EEC generates the ECAM alert "ENG X START FAULT - ENG X IGNITION FAULT".

ECAM EWD


CLB
89.0%
6
10
0.0
N1
%
6
10
0.0
EGT
°C
25
25
0.0
N2
%
5.0
0
FF
KG / H
0
FOB: 16800 KG
ENG 2 START FAULT (ENG 2 IGNITION FAULT)
PARK BRK
APU BLEED

ECAM SD


ENGINE
0
FUSED
KG
0
OIL
QT
17.0
14.0
PSI
0
14
25
°C
26
0.0
VIB N1
0.0
0.0
N2
0.1
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG


(115VU)
(22VU)
ENG
MAN START
1
2
ON
ON
MASTER1
ENG
ENG
2
ON
ON
OFF
ENG
1
MODE
NORM
IGN
START
OFF
FIRE
FAULT
FIRE
FAULT
1
2
AIR
FUEL
M
M
LP SOV
FMU
FMV
T
M
HPSOV
T
M
*
*
A
B
IGNITER
PLUGS
FFM
*
H
S
ATS
SAV
EXCITER1
EXCITER2
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B

NO LIGHT UP

- FUEL & IGNITER(S) OFF
- SAV CLOSED

AUTO RESTART

- FUEL & IGNITER(S) ON

SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

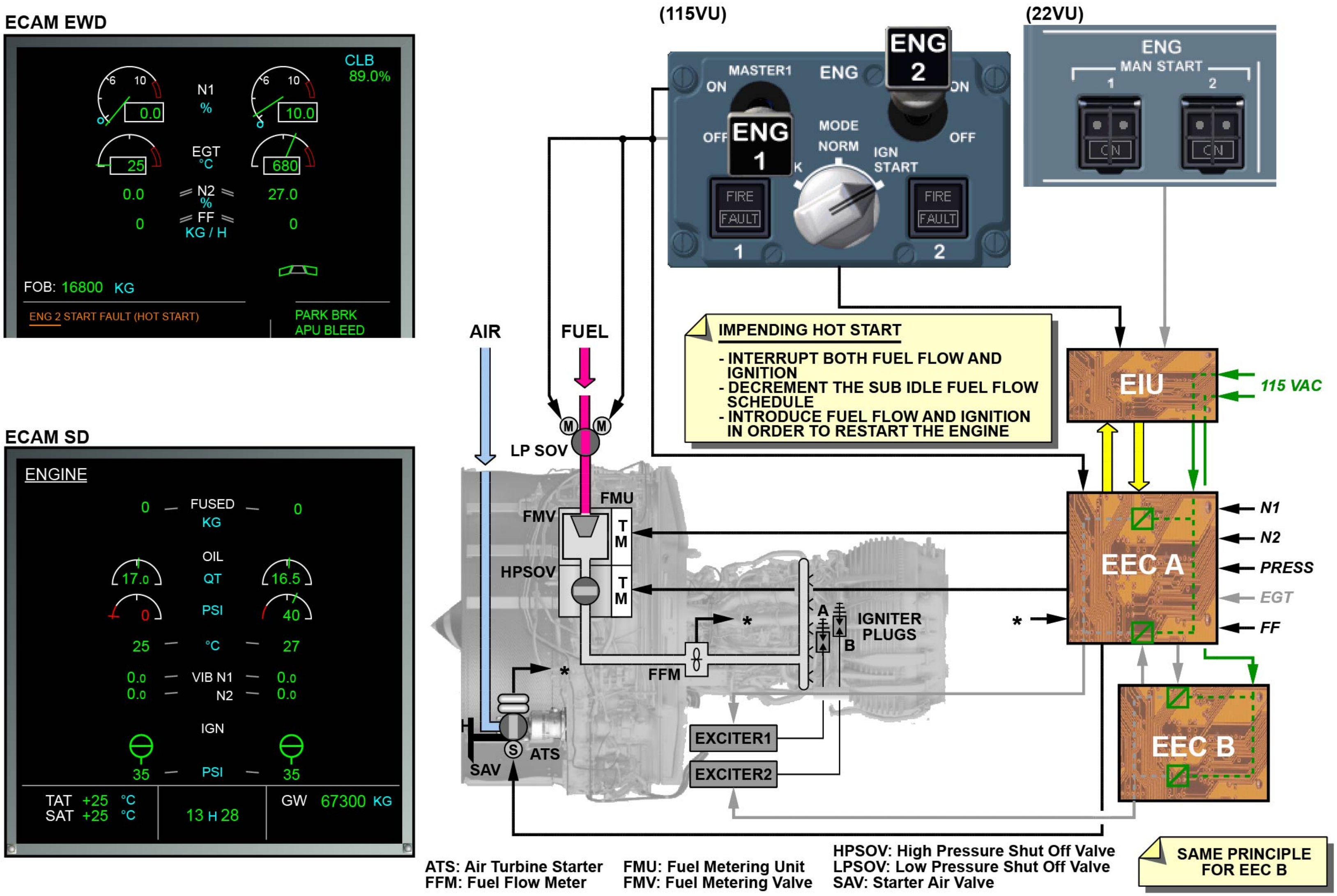
NO LIGHT UP

LEAP START FAILURES DESCRIPTION AND OPERATION (ME)

IMPENDING HOT START

The active EEC detects and accommodates Impending Hot Start conditions during starting and rollback when the EGT is within 10 degrees Celsius of the EGT Start Limit. The EGT Start Limit is 750 degrees Celsius during ground starts.
The EEC accommodation for a Hot Start is performed by the following actions order:
- Interrupt both fuel flow and ignition for 1 second,
- Decrement the sub idle fuel flow schedule,
- Introduce fuel flow and ignition in order to restart the engine.

The EEC shall dry crank the engine during Hot Start accommodation if a stall is detected during a ground auto start, a starter assisted in flight start, or a manual start.
If this auto-restart attempt fails, the start is aborted and the EEC generates the ECAM alert "ENG x START FAULT- HOT START".


ECAM EWD
CLB
89.0%
N1
%
0.0
10.0
EGT
°C
25
680
0.0
N2
%
27.0
0
FF
KG / H
0
FOB: 16800 KG
ENG 2 START FAULT (HOT START)
PARK BRK
APU BLEED
ECAM SD
ENGINE
0
FUSED
KG
0
OIL
QT
17.0
16.5
PSI
0
40
25
°C
27
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG
(115VU)
MASTER1
ENG
ON
OFF
ENG
1
ENG
2
MODE
NORM
IGN
START
OFF
FIRE
FAULT
1
2
(22VU)
ENG
MAN START
1
2
ON
AIR
FUEL
LP SOV
FMU
FMV
HPSOV
T M
FFM
A
B
IGNITER PLUGS
EXCITER1
EXCITER2
SAV
ATS
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
*

IMPENDING HOT START

- INTERRUPT BOTH FUEL FLOW AND IGNITION
- DECREMENT THE SUB IDLE FUEL FLOW SCHEDULE
- INTRODUCE FUEL FLOW AND IGNITION IN ORDER TO RESTART THE ENGINE

SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

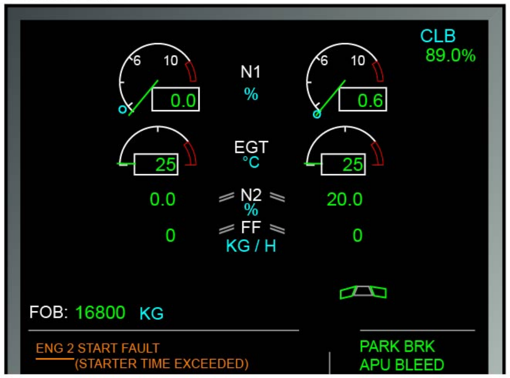
IMPENDING HOT START

LEAP START FAILURES DESCRIPTION AND OPERATION (ME)

STARTER TIME EXCEEDED

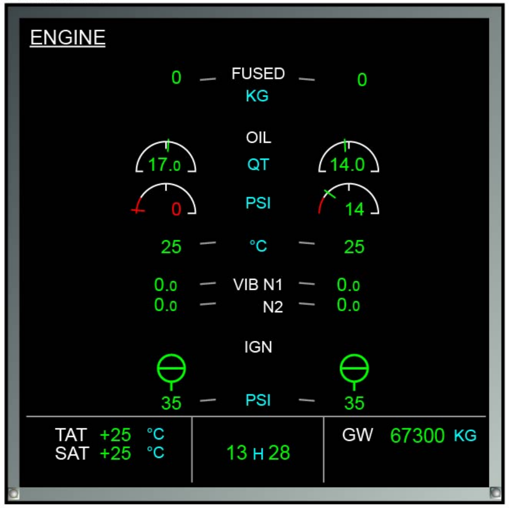
The active EEC detects Starter Duty Cycle exceedances when the SAV is open and sufficient pressure exists to drive the pneumatic starter for more than 5 minutes.
A Starter Duty Cycle exceedance during a ground auto start or a ground crank procedure aborts the start procedure.
The EEC identifies an excessive starter duty and generates the ECAM alert "ENG x START FAULT - STARTER TIME EXCEEDED".
In the other cases (ground man start, in flight auto and man starts), the EECs will only generates the ECAM alert.

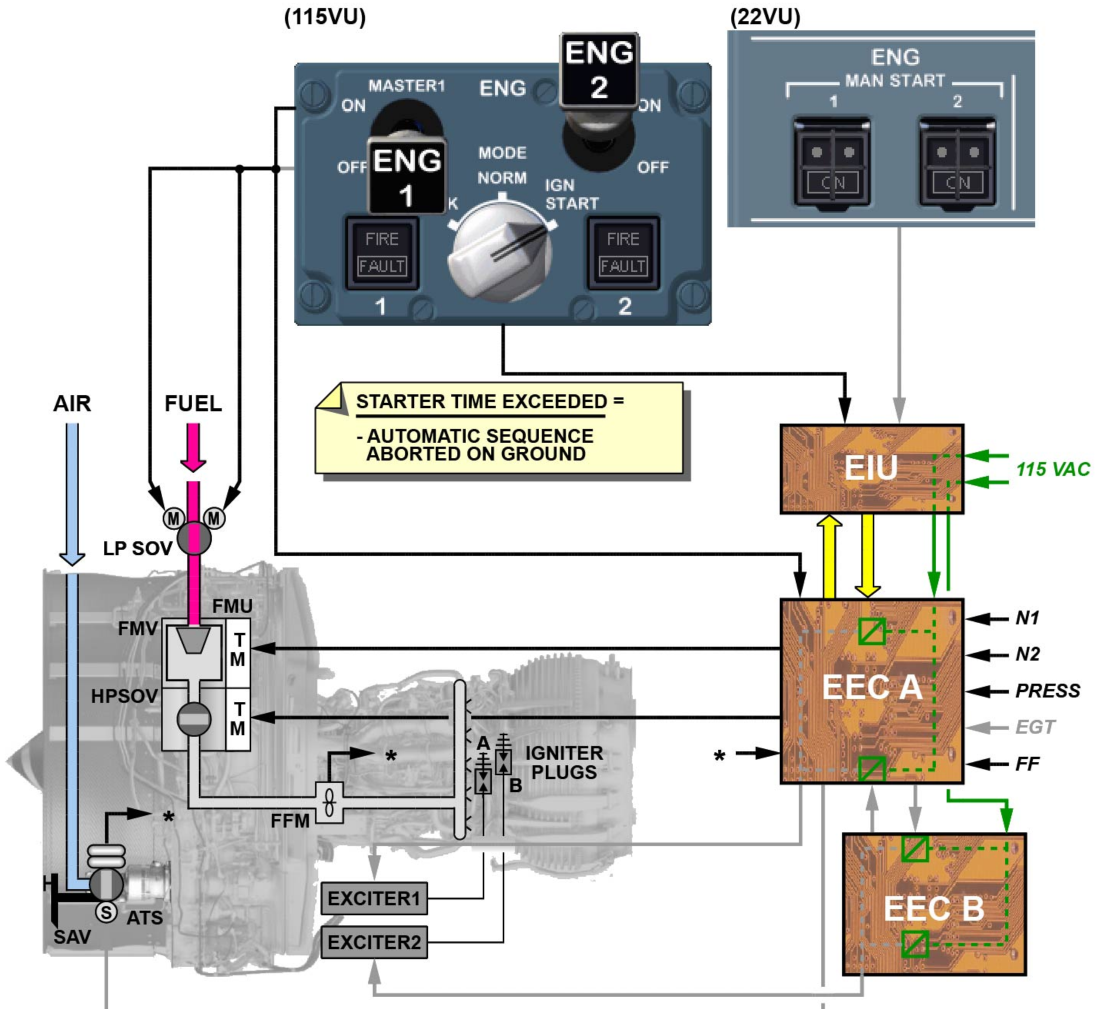
ECAM EWD


CLB
89.0%
N1
%
6
10
0.0
0.6
EGT
°C
25
25
0.0
N2
%
20.0
0
FF
KG / H
0
FOB: 16800 KG
PARK BRK
APU BLEED

ENG 2 START FAULT
(STARTER TIME EXCEEDED)

ECAM SD


ENGINE
0
FUSED
KG
0
OIL
QT
17.0
14.0
PSI
0
14
25
°C
25
0.0
VIB N1
0.0
0.0
N2
0.0
IGN
35
PSI
35
TAT +25 °C
SAT +25 °C
13 H 28
GW 67300 KG


(115VU)
(22VU)
MASTER1
ENG
ENG
2
ON
ON
OFF
ENG
1
OFF
MODE
NORM
IGN
START
FIRE
FAULT
FIRE
FAULT
1
2
ENG
MAN START
1
2
ON
ON
AIR
FUEL
LP SOV
M
M
FMU
FMV
T
M
HPSOV
T
M
FFM
*
*
A
B
IGNITER
PLUGS
*
EIU
115 VAC
EEC A
N1
N2
PRESS
EGT
FF
EEC B
EXCITER1
EXCITER2
S
ATS
SAV

STARTER TIME EXCEEDED =
- AUTOMATIC SEQUENCE ABORTED ON GROUND

SAME PRINCIPLE FOR EEC B

ATS: Air Turbine Starter
FFM: Fuel Flow Meter
FMU: Fuel Metering Unit
FMV: Fuel Metering Valve
HPSOV: High Pressure Shut Off Valve
LPSOV: Low Pressure Shut Off Valve
SAV: Starter Air Valve

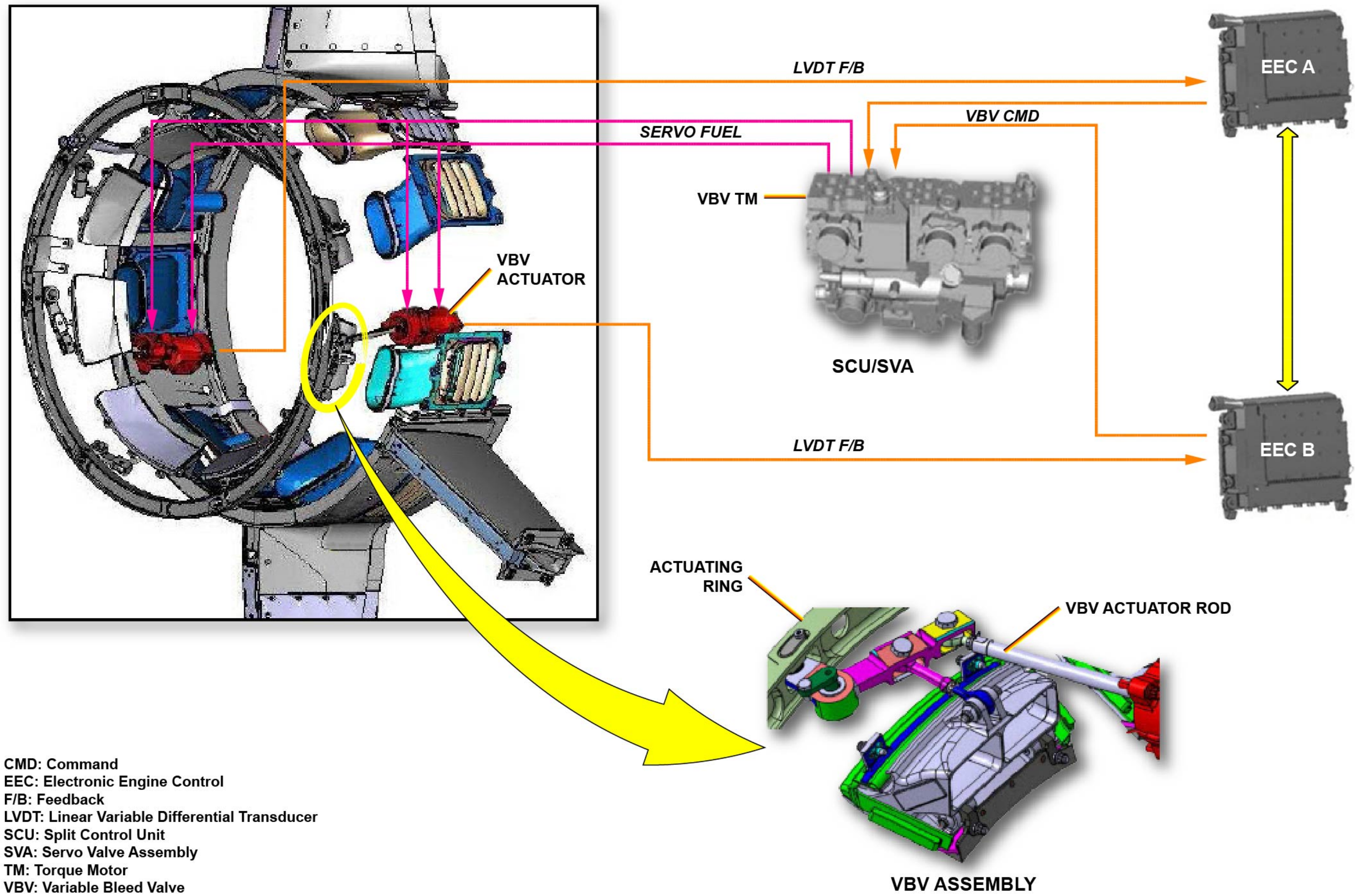
STARTER TIME EXCEEDED

AIR SYSTEM DESCRIPTION/OPERATION (3)

COMPRESSOR AIRFLOW CONTROL

VARIABLE BLEED VALVES SYSTEM

To increase the booster surge margin, part of the primary airflow is bled into the secondary gas path, through the Variable Bleed Valves (VBV) system.
The system is made of eight VBV door assemblies, one actuating ring and two VBV actuators.
Both actuators are hydraulically operated simultaneously by servo fuel from one dedicated Torque Motor (TM) in the Split Control Unit / Servo Valve Assembly (SCU/SVA). The TM is electrically controlled by the EEC in control, according to control parameters. Both actuators are mechanically connected to the actuating ring via bell cranks.
When the head chambers of the pistons are pressurized, the rods extent and the VBV doors open intrusively into the primary airflow to bypass part of the booster discharge via the VBV ducts into the fan air flow.
Each EEC receives one actuator position feedback via the actuator integrated single channel Linear Variable Differential Transducer (LVDT). The other one is exchanged by both EECs via the Cross Channel Data Link (CCDL).


LVDT F/B
EEC A
VBV CMD
SERVO FUEL
VBV TM
VBV
ACTUATOR
SCU/SVA
LVDT F/B
EEC B
ACTUATING
RING
VBV ACTUATOR ROD
VBV ASSEMBLY

CMD: Command
EEC: Electronic Engine Control
F/B: Feedback
LVDT: Linear Variable Differential Transducer
SCU: Split Control Unit
SVA: Servo Valve Assembly
TM: Torque Motor
VBV: Variable Bleed Valve

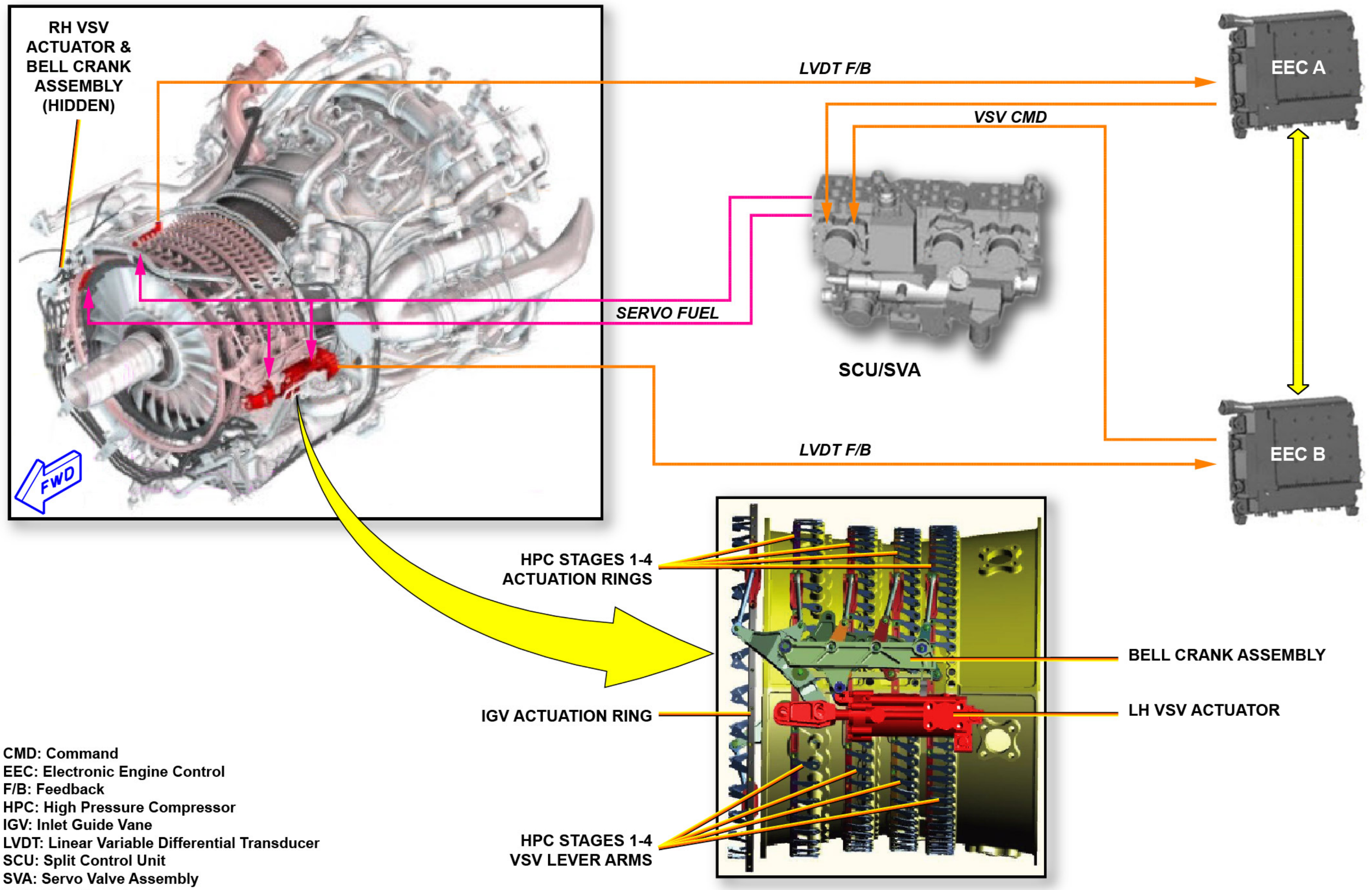
COMPRESSOR AIRFLOW CONTROL - VARIABLE BLEED VALVES SYSTEM

AIR SYSTEM DESCRIPTION/OPERATION (3)

COMPRESSOR AIRFLOW CONTROL (continued)

VARIABLE STATOR VANES SYSTEM

The Variable Stator Vane (VSV) system positions the first five HP Compressor stages of variable stator vanes to control the amount of airflow through the HP Compressor, in order to provide optimum compressor performance and to prevent compressor stall.
The system is made of two VSV actuators, two bell crank assemblies, five actuation rings and five set of VSVs including lever arms (from Inlet Guide Vanes (IGVs) to High Pressure Compressor (HPC) 4th stage).
Both actuators are hydraulically operated simultaneously by servo fuel from one dedicated TM in the SCU/SVA. The TM is electrically controlled by the EEC in control, according to control parameters.
Both actuators are mechanically linked.
The linear motion of the actuators is converted in rotating displacement of the vanes through the bell cranks, actuation rings and lever arms.
Each EEC receives one actuator position feedback via the actuator integrated single channel LVDT. The other one is exchanged by both EECs via the CCDL.


RH VSV ACTUATOR & BELL CRANK ASSEMBLY (HIDDEN)
FWD
LVDT F/B
VSV CMD
EEC A
SERVO FUEL
SCU/SVA
EEC B
LVDT F/B
HPC STAGES 1-4 ACTUATION RINGS
BELL CRANK ASSEMBLY
IGV ACTUATION RING
LH VSV ACTUATOR
HPC STAGES 1-4 VSV LEVER ARMS

CMD: Command
EEC: Electronic Engine Control
F/B: Feedback
HPC: High Pressure Compressor
IGV: Inlet Guide Vane
LVDT: Linear Variable Differential Transducer
SCU: Split Control Unit
SVA: Servo Valve Assembly
VSV: Variable Stator Vane

COMPRESSOR AIRFLOW CONTROL - VARIABLE STATOR VANES SYSTEM

AIR SYSTEM DESCRIPTION/OPERATION (3)

COMPRESSOR AIRFLOW CONTROL (continued)

START BLEED AND BOOSTER ANTI-ICE SYSTEM

The Start Bleed/Booster Anti Ice (SB/BAI) system bleeds 7th stage air from the HP compressor during transient starting conditions in order to improve the starting performances or to provide heating air to the booster during icing conditions.

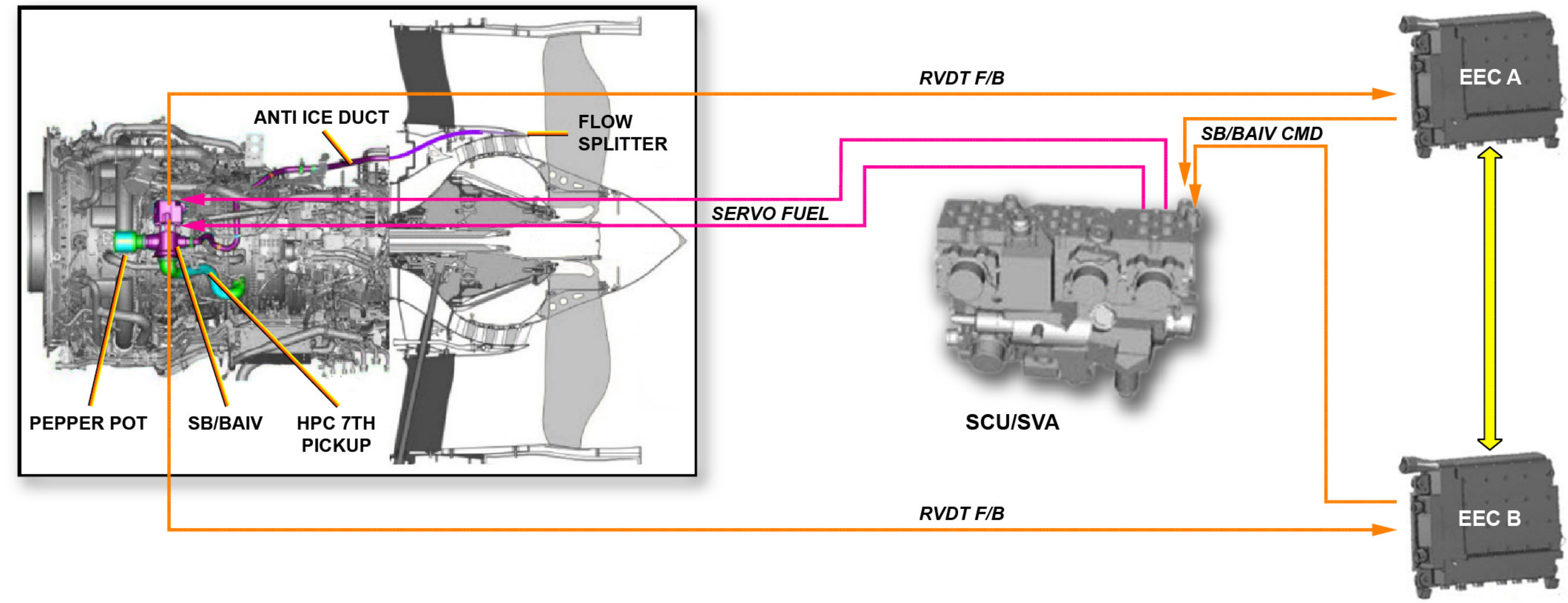
The Start Bleed/Booster Anti Ice Valve (SB/BAIV) consists of a single inlet (7th stage) and two outlets. An internal ball mechanism directs air through the two exit ports: one to the core compartment for start bleed function and the other one to the flow splitter leading edge for booster anti-ice function.

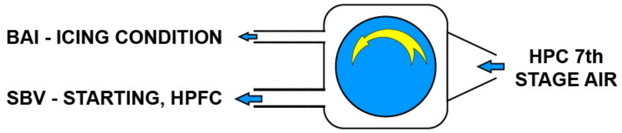
For BAI, the HPC 7th air pickup is ducted by several hoses to the flow splitter, which includes notches for hot gas evacuation to the outer surface.

For SB, the bleed air exits the valve and is vented through a pepper pot device that diffuses the air under the cowling in the core area.

The SB/BAIV actuator is hydraulically operated by servo fuel from one dedicated TM in the SCU/SVA. The TM is electrically controlled by the EEC in control, according to preset parameters.

A dual channel Rotary Variable Differential Transducer (RVDT), inside the rotary fuel actuator, provides valve position feedback to both EECs.


RVDT F/B
EEC A
ANTI ICE DUCT
FLOW SPLITTER
SB/BAIV CMD
SERVO FUEL
PEPPER POT
SB/BAIV
HPC 7TH PICKUP
SCU/SVA
RVDT F/B
EEC B


BAI - ICING CONDITION
SBV - STARTING, HPFC
HPC 7th STAGE AIR

ROTATION	0°	30°	60°	90°
BAI Flow (% open)	0	100	100	100
SBV Flow (% open)	0	0	50	100

BAI MODULATION (0° – 30°)

SBV MODULATION (60° – 90°)

BAIV: Booster Anti Ice Valve
CMD: Command
EEC: Electronic Engine Control
F/B: Feedback
HPC: High Pressure Compressor
RVDT: Rotary Variable Differential Transducer
SB: Start Bleed
SBV: Start Bleed Valve
SCU: Split Control Unit
SVA: Servo Valve Assembly

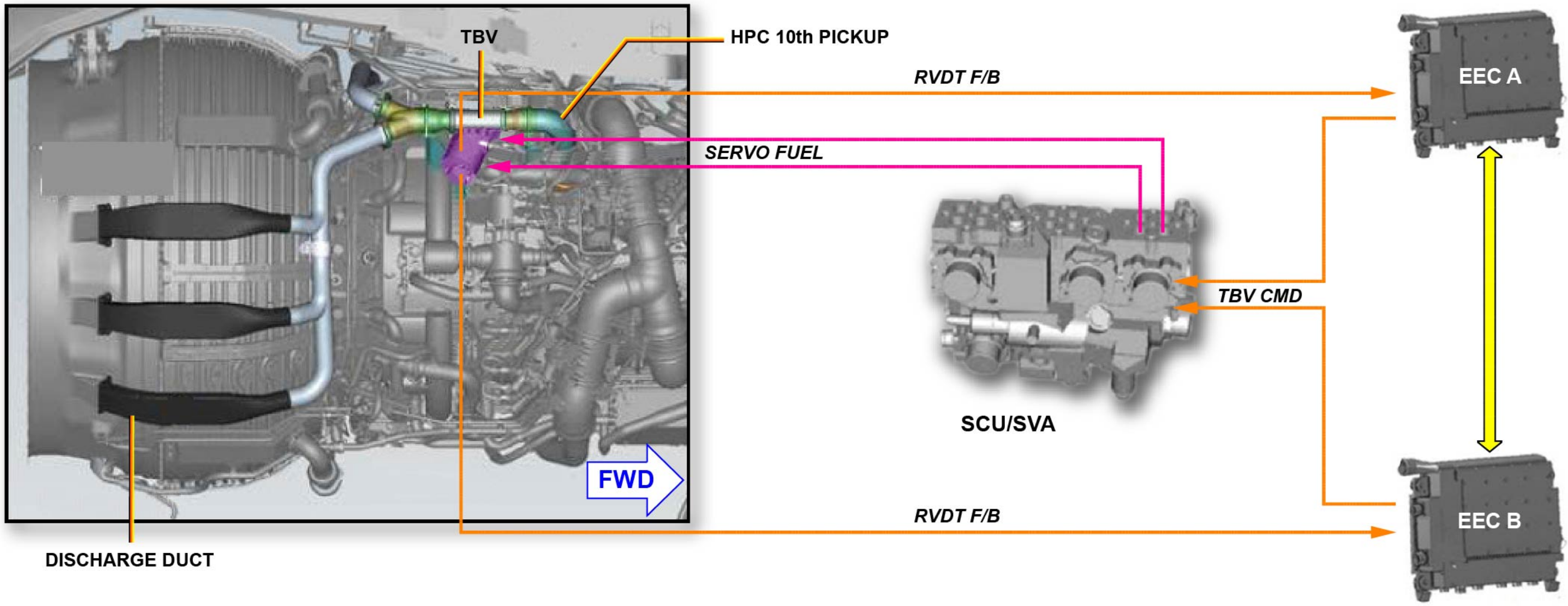
COMPRESSOR AIRFLOW CONTROL - START BLEED AND BOOSTER ANTI-ICE SYSTEM

AIR SYSTEM DESCRIPTION/OPERATION (3)

COMPRESSOR AIRFLOW CONTROL (continued)

TRANSIENT BLEED SYSTEM

The Transient Bleed Valve (TBV) system discharges part of the HPC 10th stage air into the turbine exhaust in order to unload the compressor during engine decelerations for increased stall margin.
The system consists of one TBV (including one actuator, one butterfly body valve and a dual LVDT), manifolds and six exhaust ducts (three on each side).
The TBV actuator is hydraulically operated by servo fuel from one dedicated TM in the SCU/SVA. The TM is electrically controlled by the EEC in control, according to preset parameters.
A dual channel RVDT, inside the rotary fuel actuator, provides valve position feedback to both EECs.


TBV
HPC 10th PICKUP
RVDT F/B
SERVO FUEL
EEC A
SCU/SVA
TBV CMD
FWD
RVDT F/B
EEC B
DISCHARGE DUCT

CMD: Command
EEC: Electronic Engine Control
F/B: Feedback
HPC: High Pressure Compressor
LVDT: Linear Variable Differential Transducer
SCU: Split Control Unit
SVA: Servo Valve Assembly
TBV: Transient Bleed Valve

COMPRESSOR AIRFLOW CONTROL - TRANSIENT BLEED SYSTEM

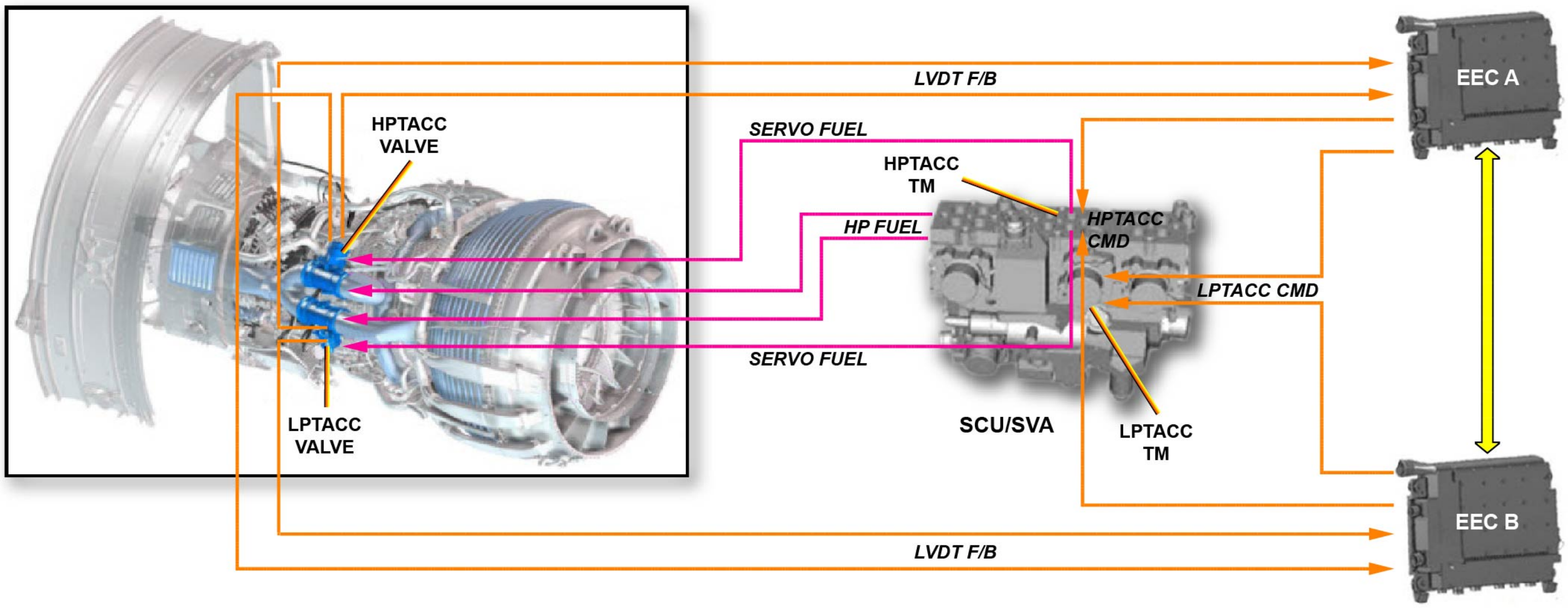
AIR SYSTEM DESCRIPTION/OPERATION (3)

COOLING

HPT & LPT ACTIVE CLEARANCE CONTROL SYSTEM

The HPTACC and LPTACC system regulates airflow to the exterior of the high and low pressure turbine cases. The cooling air is used to optimize the clearances between the cases and the rotor blades in order to decrease the specific fuel consumption. Fan air enters the circuit through a louver and is splitted in two sub-circuits where it is metered by each ACC individual valve.
The HPTACC and LPTACC valves are two separate, but identical, butterfly-type valves. Each valve actuator is hydraulically operated by servo fuel from one dedicated TM in the SCU/SVA. The TM is electrically controlled by the EEC in control, according to preset parameters.
A dual channel LVDT, inside each fuel actuator, provides valve position feedback to both EECs.

NOTE: The actuator extension chamber is supplied by modulated servo fuel whereas the rod chamber is supplied by regulated High Pressure fuel.


LVDT F/B
EEC A
SERVO FUEL
HPTACC VALVE
HPTACC TM
HP FUEL
HPTACC CMD
LPTACC CMD
SERVO FUEL
SCU/SVA
LPTACC VALVE
LPTACC TM
EEC B
LVDT F/B

CMD: Command
EEC: Electronic Engine Control
F/B: Feedback
HP: High Pressure
HPTACC: High Pressure Turbine Active Clearance Control
LPTACC: Low Pressure Turbine Active Clearance Control
LVDT: Linear Variable Differential Transducer
SCU: Split Control Unit
SVA: Servo Valve Assembly
TM: Torque Motor

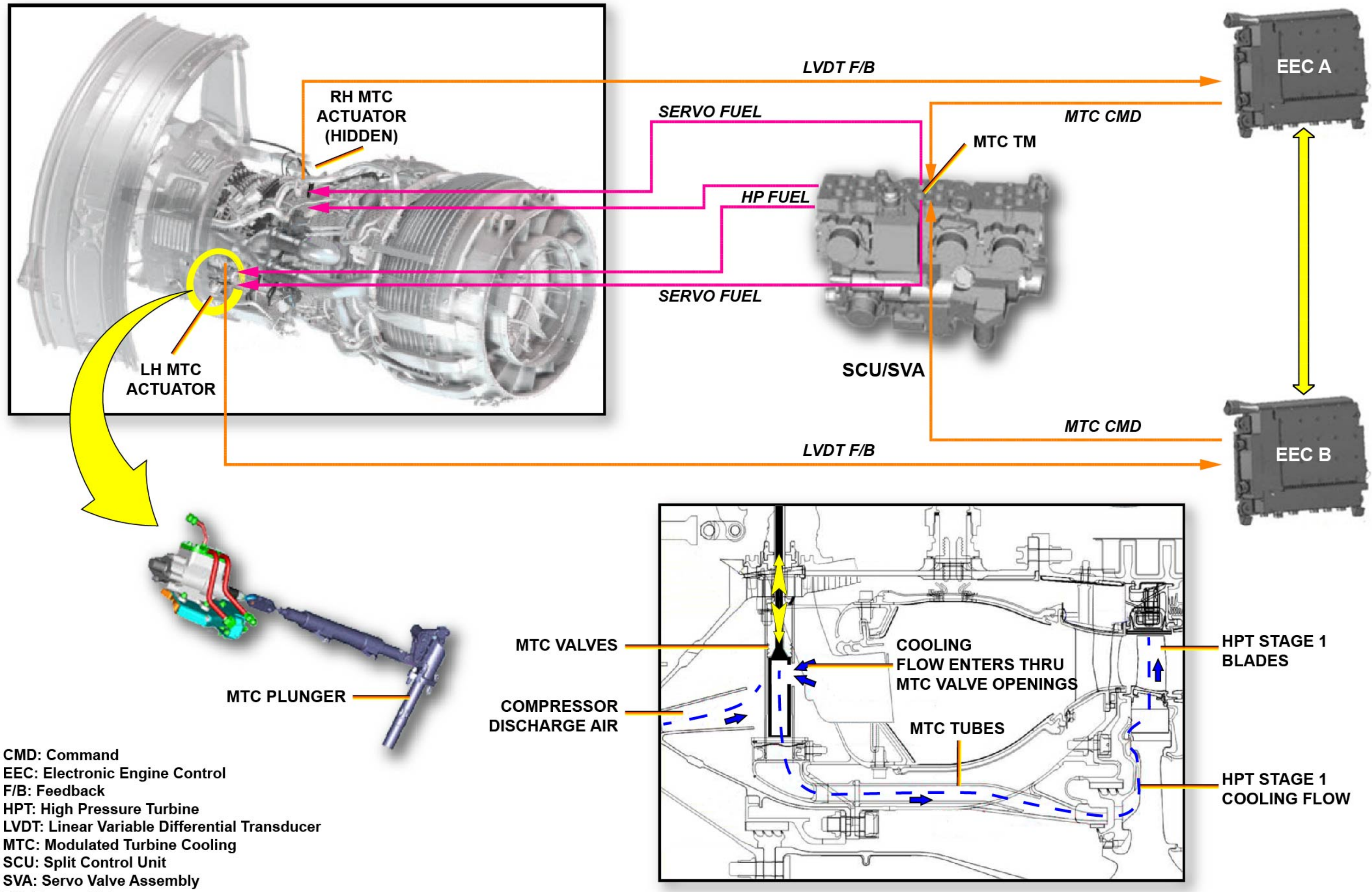
COOLING - HPT & LPT ACTIVE CLEARANCE CONTROL SYSTEM

AIR SYSTEM DESCRIPTION/OPERATION (3)

COOLING (continued)

MODULATED TURBINE COOLING SYSTEM

The Modulated Turbine Cooling (MTC) system reduces the HPT turbine blades cooling at low power in order to limit air leaks and to decrease the specific fuel consumption.
The cooling flow from the HPC 10th stage to the HPT 1st stage turbine blades is increased by the opening of the two MTC Valves (MTCVs) at high power.
The MTCVs are two independent plunger-type valves connected to their respective actuator via a push/pull rod linkage mechanism. Both valve actuators are hydraulically operated simultaneously by servo fuel from one dedicated TM in the SCU/SVA. The TM is electrically controlled by the EEC in control, according to preset parameters. The actuators are commanded fully open or fully closed.
Each EEC receives one valve position feedback via the actuator integrated single channel LVDT. The other one is exchanged by both EECs via the CCDL.


LVDT F/B
RH MTC ACTUATOR (HIDDEN)
SERVO FUEL
MTC CMD
EEC A
MTC TM
HP FUEL
SERVO FUEL
LH MTC ACTUATOR
SCU/SVA
MTC CMD
LVDT F/B
EEC B
MTC VALVES
COOLING FLOW ENTERS THRU MTC VALVE OPENINGS
HPT STAGE 1 BLADES
MTC PLUNGER
COMPRESSOR DISCHARGE AIR
MTC TUBES
HPT STAGE 1 COOLING FLOW

CMD: Command
EEC: Electronic Engine Control
F/B: Feedback
HPT: High Pressure Turbine
LVDT: Linear Variable Differential Transducer
MTC: Modulated Turbine Cooling
SCU: Split Control Unit
SVA: Servo Valve Assembly
TM: Torque Motor

COOLING - MODULATED TURBINE COOLING SYSTEM

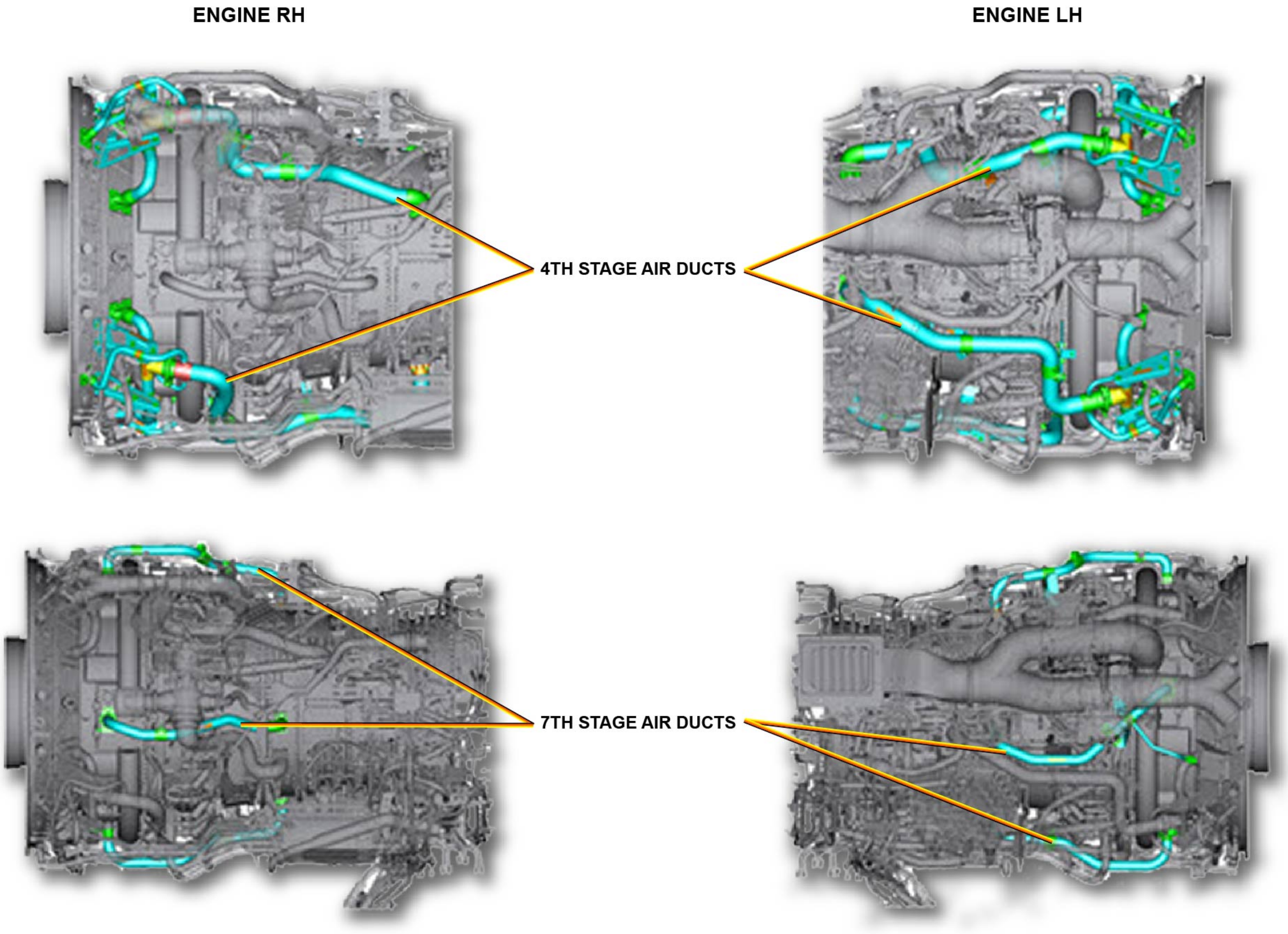
AIR SYSTEM DESCRIPTION/OPERATION (3)

COOLING (continued)

TURBINE COOLING

The HPC 4th stage air circuit delivers dedicated cooling to the Turbine Center Frame (TCF) and TCF struts. The circuit comprises four ducts located circumferentially around the engine that attach to four bolt flange ports on the forward compressor case for the pickup. The air is directed aft and splits into three separate branches that attach to four bolt flange ports on the TCF for the discharge.

The HPC 7th stage air circuit delivers dedicated cooling to the HP turbine (HPT). The circuit comprises four ducts located circumferentially around the engine that attach to four bolt flange ports on the aft compressor case for the pickup and on the HPT case for the discharge. The air is directed aft.


ENGINE RH
ENGINE LH
4TH STAGE AIR DUCTS
7TH STAGE AIR DUCTS

COOLING - TURBINE COOLING

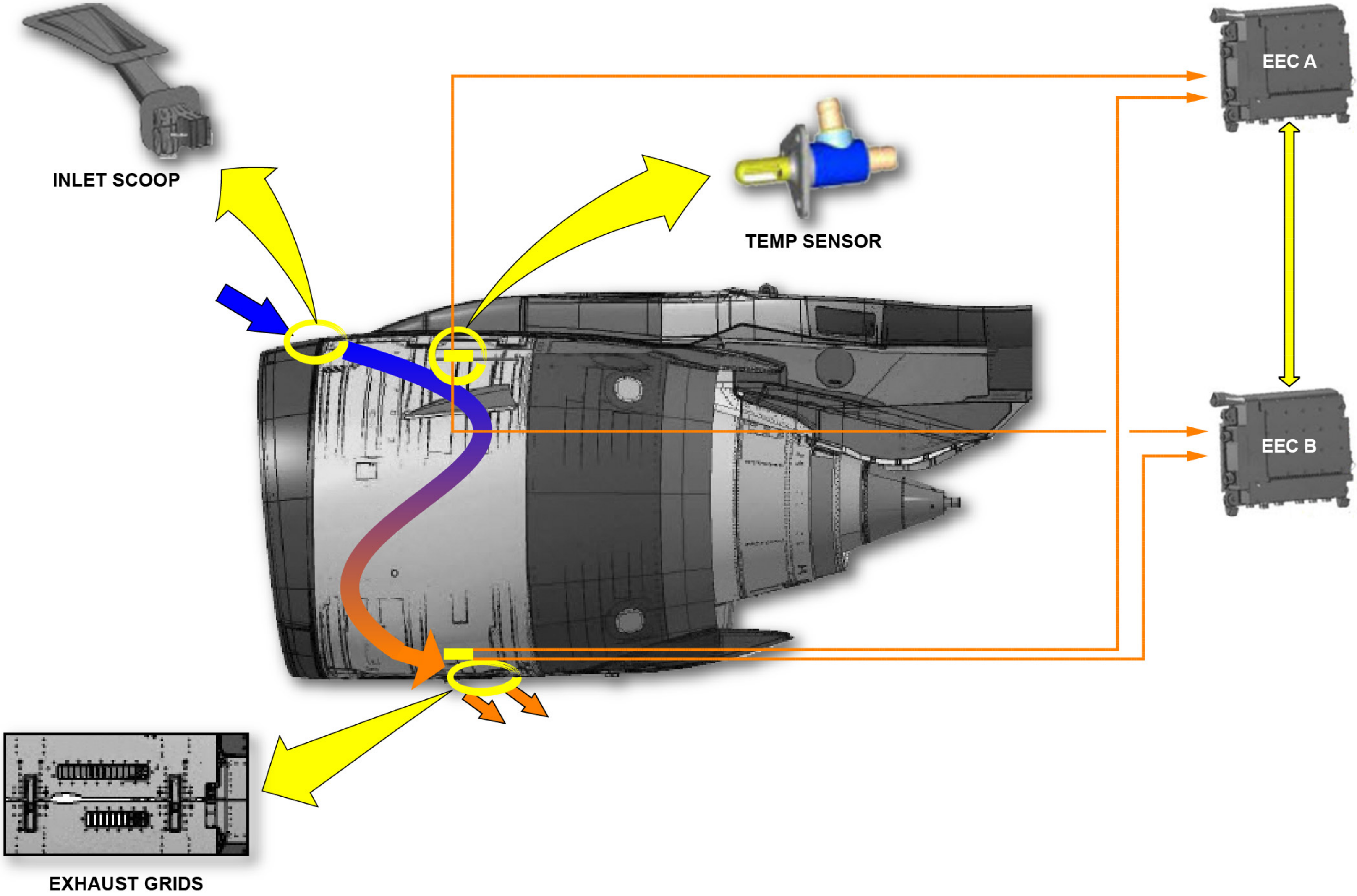
AIR SYSTEM DESCRIPTION/OPERATION (3)

COOLING (continued)

FAN COMPARTMENT AND ACCESSORY COOLING

The fan compartment cooling is achieved through a passive ventilation system with external air. When the aircraft is moving, the airflow is circulated from the top ventilation scoop to the ventilation grids and split line at the bottom of the fan cowl.

The Fan Overheat Detector system monitors the fan area for any excessive temperature due to a bleed air leak and sends the corresponding signal to the EECs. There are two dual sensors in the fan case, one at the 12 o'clock position next to the starter duct and the other at the 6 o'clock position next to the Nacelle Anti-Icing (NAI) duct.


INLET SCOOP
TEMP SENSOR
EEC A
EEC B
EXHAUST GRIDS

COOLING - FAN COMPARTMENT AND ACCESSORY COOLING

AIR SYSTEM DESCRIPTION/OPERATION (3)

COOLING (continued)

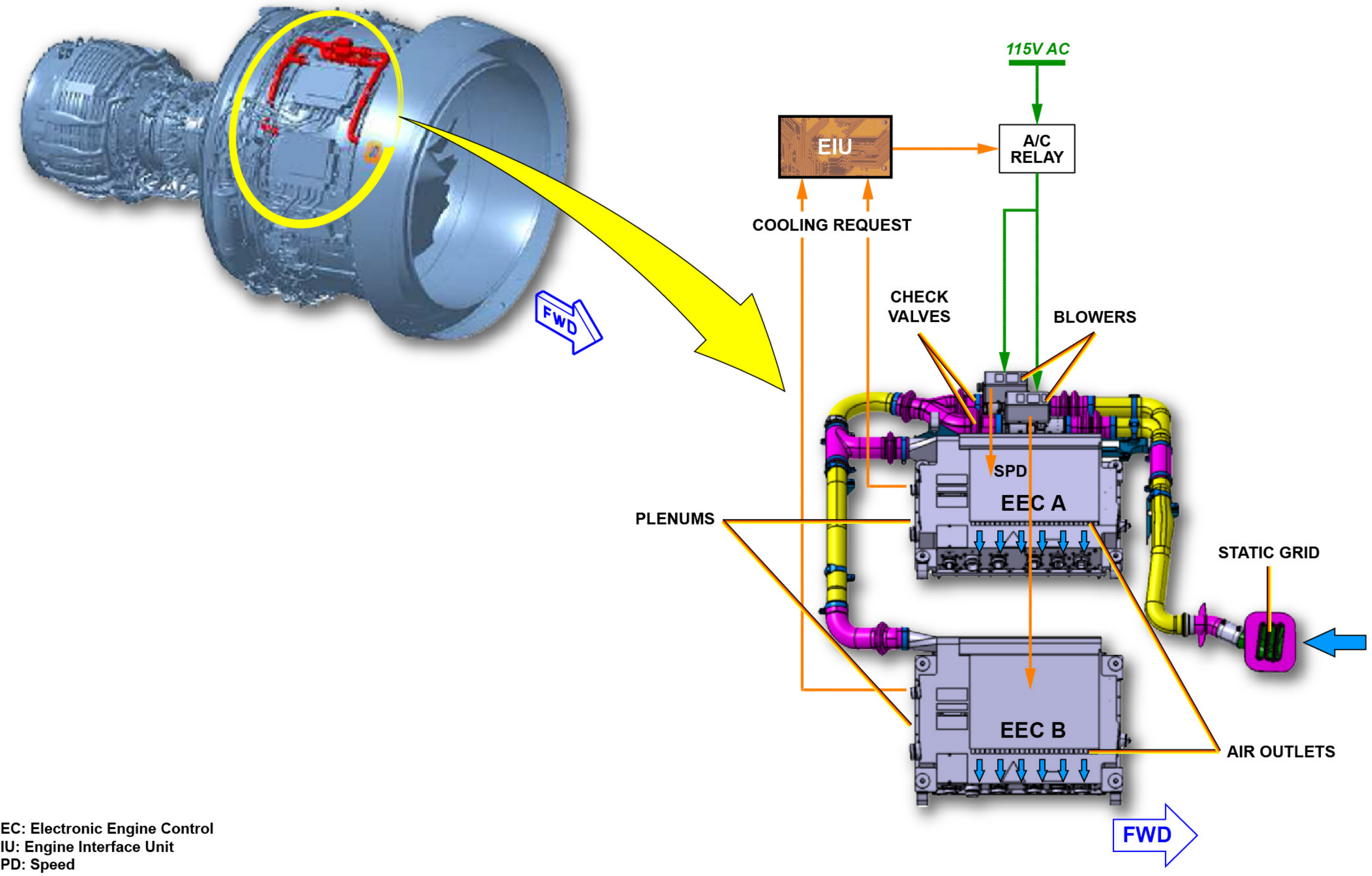
EEC COOLING

The EEC Cooling system provides additional dedicated cooling to both EECs in specific conditions. Otherwise the fan compartment ventilation is sufficient to cool down the EECs.

The EEC cooling system consists of two blowers installed in parallel, which pull outside air through the static grid into the EEC plenums. The flow is then exhausted in the fan compartment via EEC air outlets.

When any EEC detects an internal high temperature on ground, it sends the demand to the EIU that controls an independent power supply relay to power both blowers. Each EEC receives one blower speed sensor signal for confirmation.

Each blower is fitted with an electronic control system, thermal protections and an outlet check valve.


115V AC
EIU
A/C RELAY
COOLING REQUEST
CHECK VALVES
BLOWERS
SPD
EEC A
PLENUMS
STATIC GRID
EEC B
AIR OUTLETS
FWD
FWD

EEC: Electronic Engine Control
EIU: Engine Interface Unit
SPD: Speed

COOLING - EEC COOLING

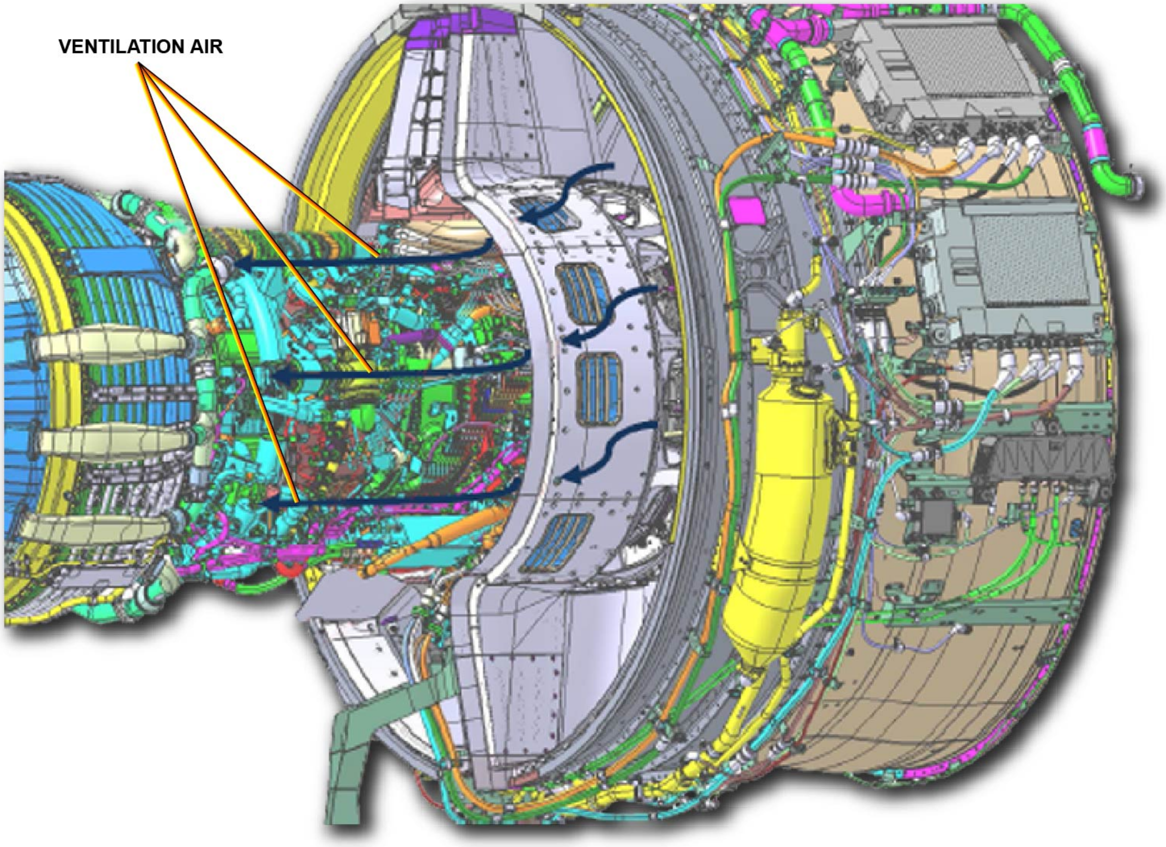
AIR SYSTEM DESCRIPTION/OPERATION (3)

COOLING (continued)

CORE COMPARTMENT VENTILATION SYSTEM

The Core Compartment Ventilation (CCV) system removes hot air and vapors from the core compartment to the outside. The CCV system is a passive system that redirects a small flow from the fan stream via six cooling holes drilled in the Fan Extension Ring (FER) to the core compartment. The air is then discharged overboard through an annular gap at the rear of the engine formed by the Inner Fixed Structure (IFS) and the Nozzle.

CORE COMPARTMENT VENTILATION SYSTEM



COOLING - CORE COMPARTMENT VENTILATION SYSTEM

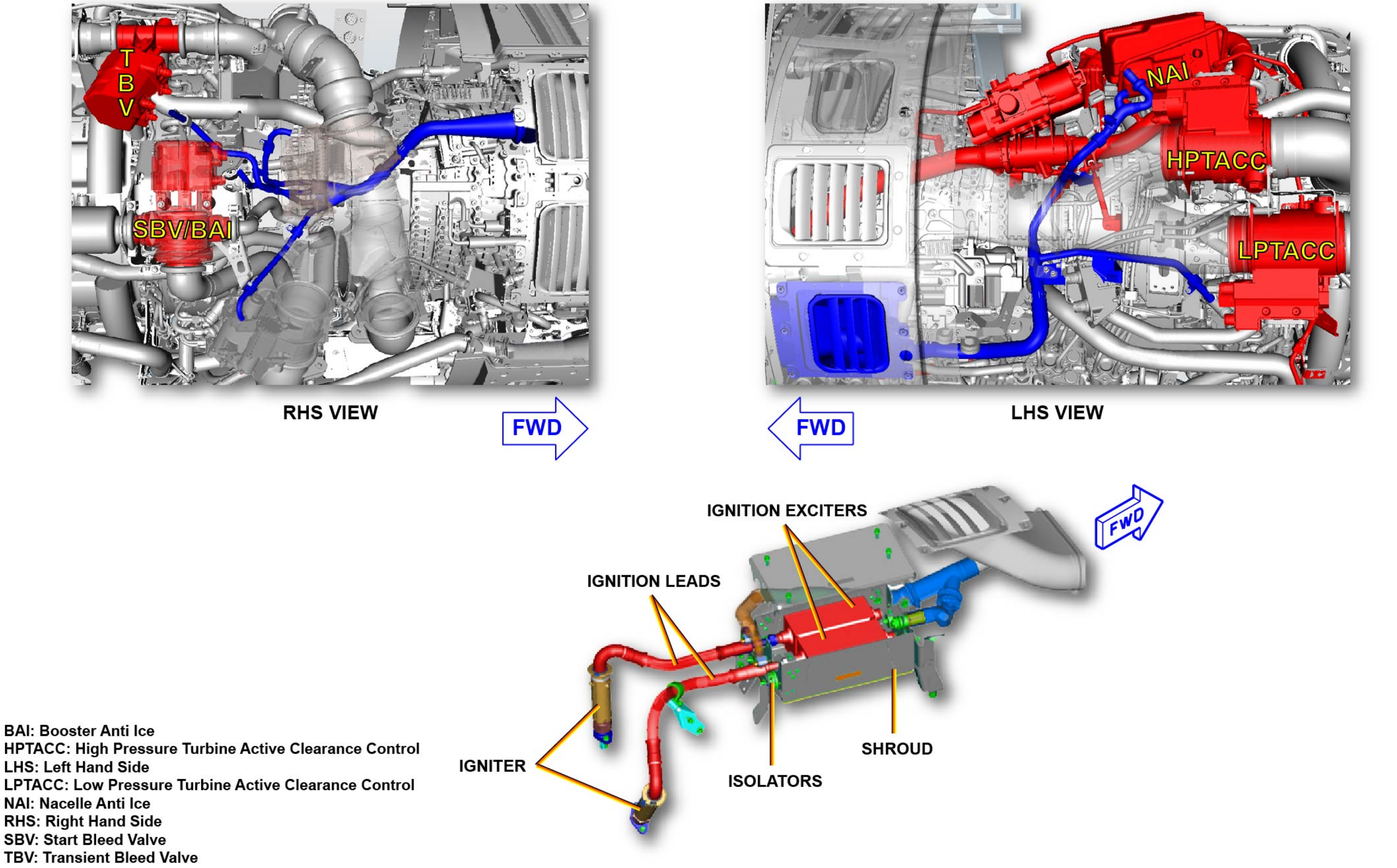
AIR SYSTEM DESCRIPTION/OPERATION (3)

COOLING (continued)

CORE COMPARTMENT COOLING SYSTEM

The Core Compartment Cooling (CCC) system provides dedicated cooling for some under cowl components subject to high temperature. They are divided in three groups.
The CCC system is a passive system that directs part of three VBVs air discharge to three independent manifolds to blow the related components. The bottom manifold provides cooling to the inside of the exciter box and the ignition leads, the right one provides cooling to the SBV/BAIV and the TBV and the left one provides cooling to the NAIV, LPTACCV and HPTACCV.
The CCC system is only supplied by booster air discharge when the VBV doors are open (at ground idle, up to accelerated N1).

CORE COMPARTMENT COOLING SYSTEM


T
B
V
SBV/BAI
RHS VIEW
FWD
NAI
HPTACC
LPTACC
FWD
LHS VIEW
IGNITION EXCITERS
FWD
IGNITION LEADS
IGNITER
ISOLATORS
SHROUD

BAI: Booster Anti Ice
HPTACC: High Pressure Turbine Active Clearance Control
LHS: Left Hand Side
LPTACC: Low Pressure Turbine Active Clearance Control
NAI: Nacelle Anti Ice
RHS: Right Hand Side
SBV: Start Bleed Valve
TBV: Transient Bleed Valve

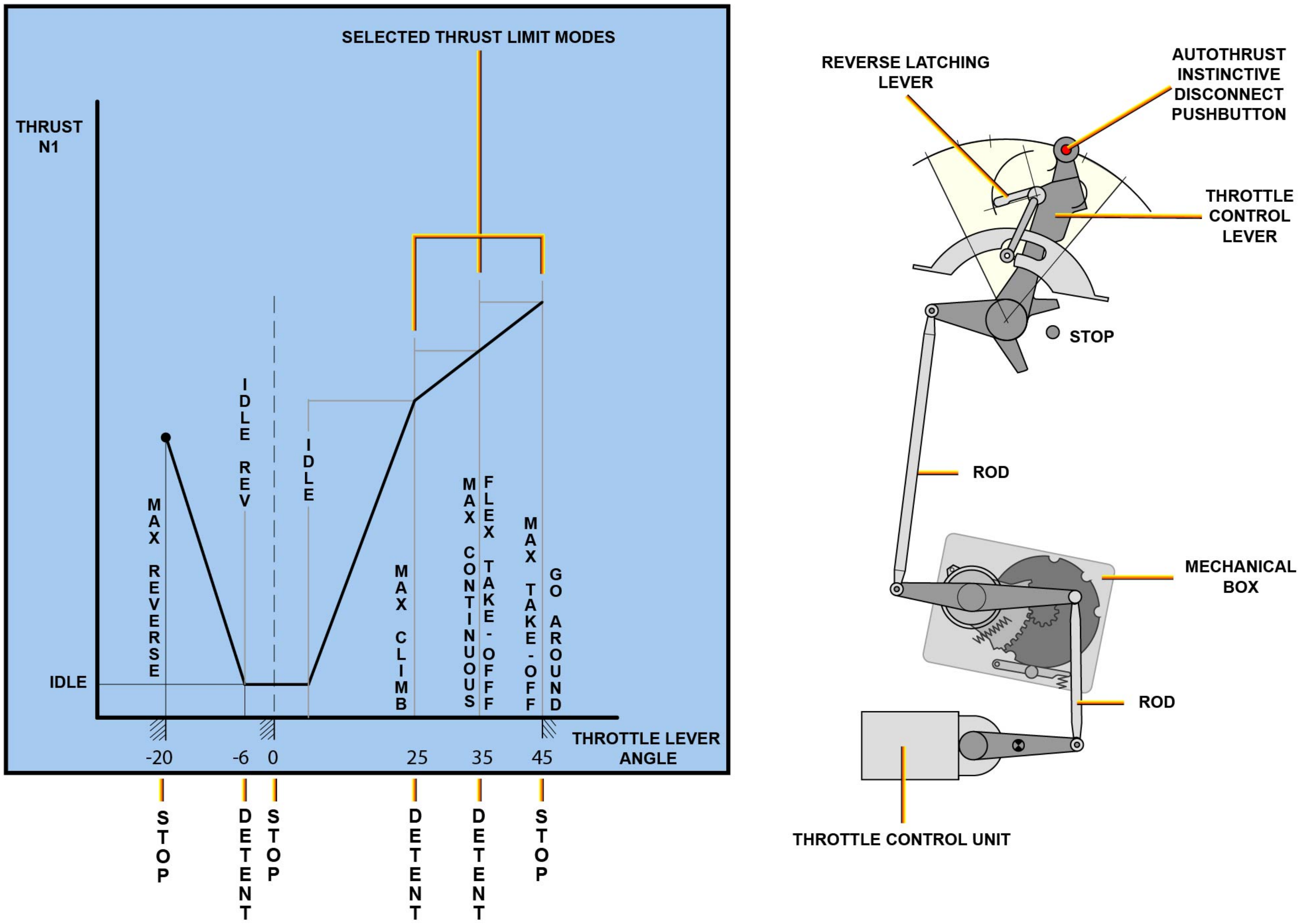
COOLING - CORE COMPARTMENT COOLING SYSTEM

THROTTLE CONTROL SYSTEM D/O

THROTTLE CONTROL LEVER

The throttle control handle comprises:
- A throttle control lever which incorporates stop devices, autothrust instinctive disconnect pushbutton switch,
- A graduated fixed sector,
- A reverse latching lever.

The throttle control lever is linked to a mechanical rod.
This rod drives the input lever of the throttle control artificial feel unit.
The throttle control lever moves over a range from -20 deg.Throttle Lever Angle (TLA) to +45 deg.TLA:
-20 degrees TLA corresponds to Reverser Full Throttle stop,
+45 degrees TLA corresponds to Forward Full Throttle stop.
The intermediate mechanical stop (Idle) is set to 0 deg.TLA.
This stop is overridden when the reverse latching lever is pulled up for selection of the reverse power.
This stop is reset as soon as the throttle control lever is selected back to forward thrust area.
In the forward thrust area, there are two detent points, the MAX CLIMB detent point set at 25 deg.TLA and the MAX CONTINUOUS/FLEX TAKE-OFF detent point set at 35 deg.TLA.
In the reverse thrust throttle range; there is one detent point at -6 deg.TLA.
This position agrees with the selection of the thrust reverser command and the Reverse Idle setting.
In the middle throttle range (0 deg. to 35 deg.TLA), the autothrust function can be active if engaged. This range agrees with the selection of MAX CLIMB or MAX CONTINUOUS thrust limit mode (in single operation).
If the autothrust is not engaged, the engine control is manual.
In the forward range (35 deg. to 45 deg.TLA), the autothrust function cannot be activated (except in alpha floor condition).
This range agrees with the selection of FLEX TAKE-OFF/MAX TAKE-OFF (GO AROUND) Mode.


SELECTED THRUST LIMIT MODES
THRUST N1
IDLE
MAX REVERSE
IDLE REV
IDLE
MAX CLIMB
MAX CONTINUOUS
FLEX TAKE-OFF
MAX TAKE-OFF
GO AROUND
THROTTLE LEVER ANGLE
-20
-6
0
25
35
45
STOP
DETENT
STOP
DETENT
DETENT
STOP
REVERSE LATCHING LEVER
AUTOTHRUST INSTINCTIVE DISCONNECT PUSHBUTTON
THROTTLE CONTROL LEVER
STOP
ROD
MECHANICAL BOX
ROD
THROTTLE CONTROL UNIT

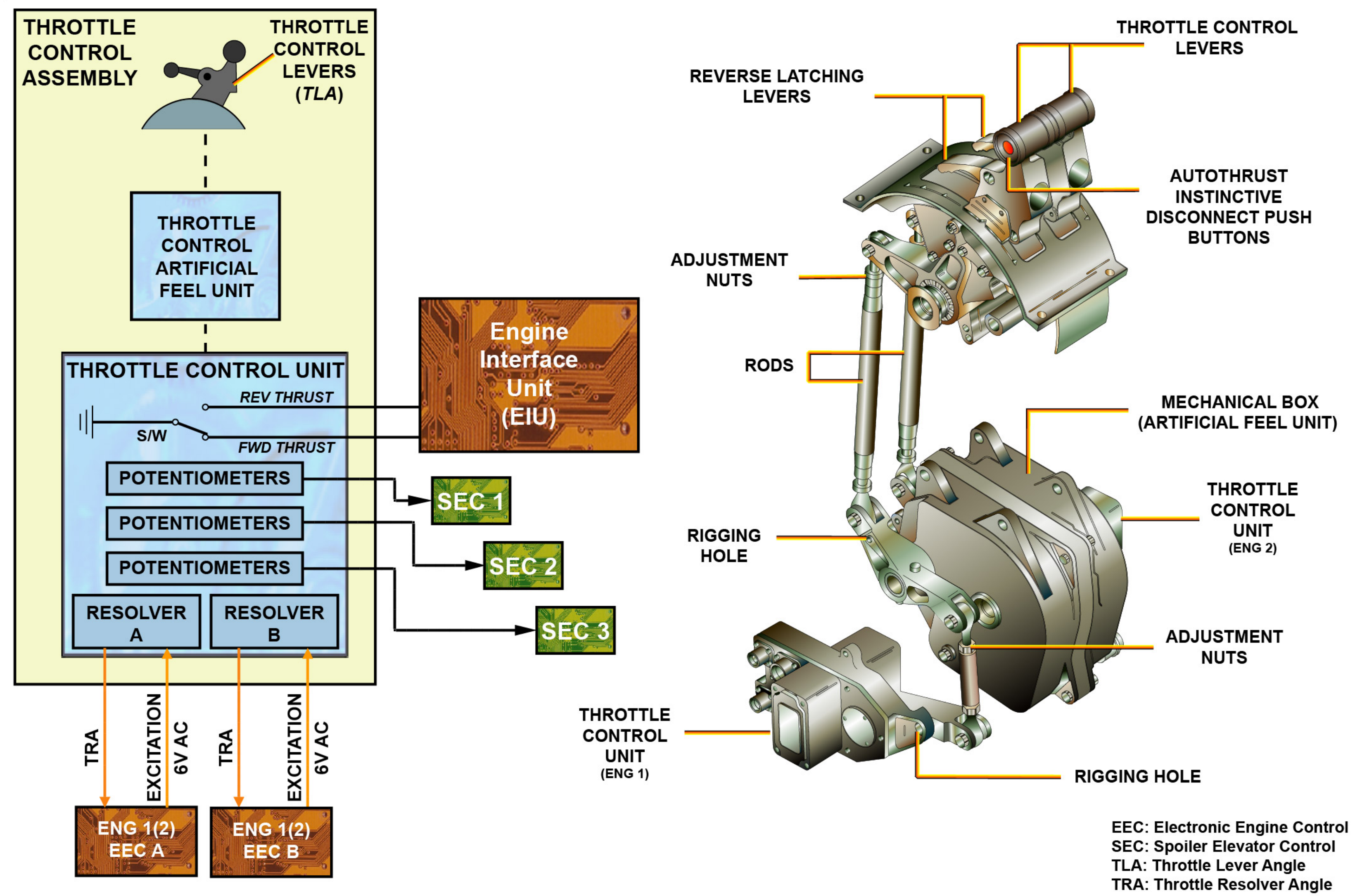
THROTTLE CONTROL LEVER

THROTTLE CONTROL SYSTEM D/O

THROTTLE CONTROL UNIT

A mechanical rod transmits the throttle control lever movement. It connects the throttle artificial feel unit to the input lever of the throttle control unit. Each throttle control unit comprises:
- An input lever,
- Mechanical stops, which limit the angular range,
- 2 resolvers (one resolver per Electronic Engine Control (EEC)),
- 6 potentiometers (which send signals to Spoiler Elevator Computers (SECs) 1, 2 and3),
- A device, which drives the resolver and the potentiometer,
- A pin device for rigging the resolvers and potentiometers,
- 1 switch whose signal is dedicated to the Engine Interface Unit (EIU),
- 2 output electrical connectors.

The input lever drives two gear sectors assembled face to face. Each sector drives a set of resolvers and potentiometers.
The relationship between the Throttle Lever Angle (TLA) and Throttle Resolver Angle (TRA) is linear and (1 deg.TLA = 1.9 TRA).
The accuracy of the throttle control unit (error between the input lever position and the resolver angle) is 0.5 deg.TRA.
The maximum discrepancy between the signals generated by two resolvers is 0.25 deg.TRA.
The TLA resolver operates in two quadrants. The first quadrant is used for positive angles and the second quadrant for negative angles.
Each resolver is dedicated to one EEC and receives its electrical excitation current (6V AC) from the related EEC.
The EECs consider, as a resolver position signal failure, a throttle resolver angle value less than -47.5 deg. or greater than 98.8 deg.
They include a resolver fault accommodation logic. This logic allows engine operation after a failure or a complete loss of the throttle resolver position signal.


THROTTLE CONTROL ASSEMBLY
THROTTLE CONTROL LEVERS (*TLA*)
THROTTLE CONTROL ARTIFICIAL FEEL UNIT
THROTTLE CONTROL UNIT
REV THRUST
S/W
FWD THRUST
POTENTIOMETERS
POTENTIOMETERS
POTENTIOMETERS
RESOLVER A
RESOLVER B
Engine Interface Unit (EIU)
SEC 1
SEC 2
SEC 3
TRA
EXCITATION 6V AC
TRA
EXCITATION 6V AC
ENG 1(2) EEC A
ENG 1(2) EEC B
THROTTLE CONTROL LEVERS
REVERSE LATCHING LEVERS
AUTOTHRUST INSTINCTIVE DISCONNECT PUSH BUTTONS
ADJUSTMENT NUTS
RODS
MECHANICAL BOX (ARTIFICIAL FEEL UNIT)
THROTTLE CONTROL UNIT (ENG 2)
RIGGING HOLE
ADJUSTMENT NUTS
THROTTLE CONTROL UNIT (ENG 1)
RIGGING HOLE

EEC: Electronic Engine Control
SEC: Spoiler Elevator Control
TLA: Throttle Lever Angle
TRA: Throttle Resolver Angle

THROTTLE CONTROL UNIT

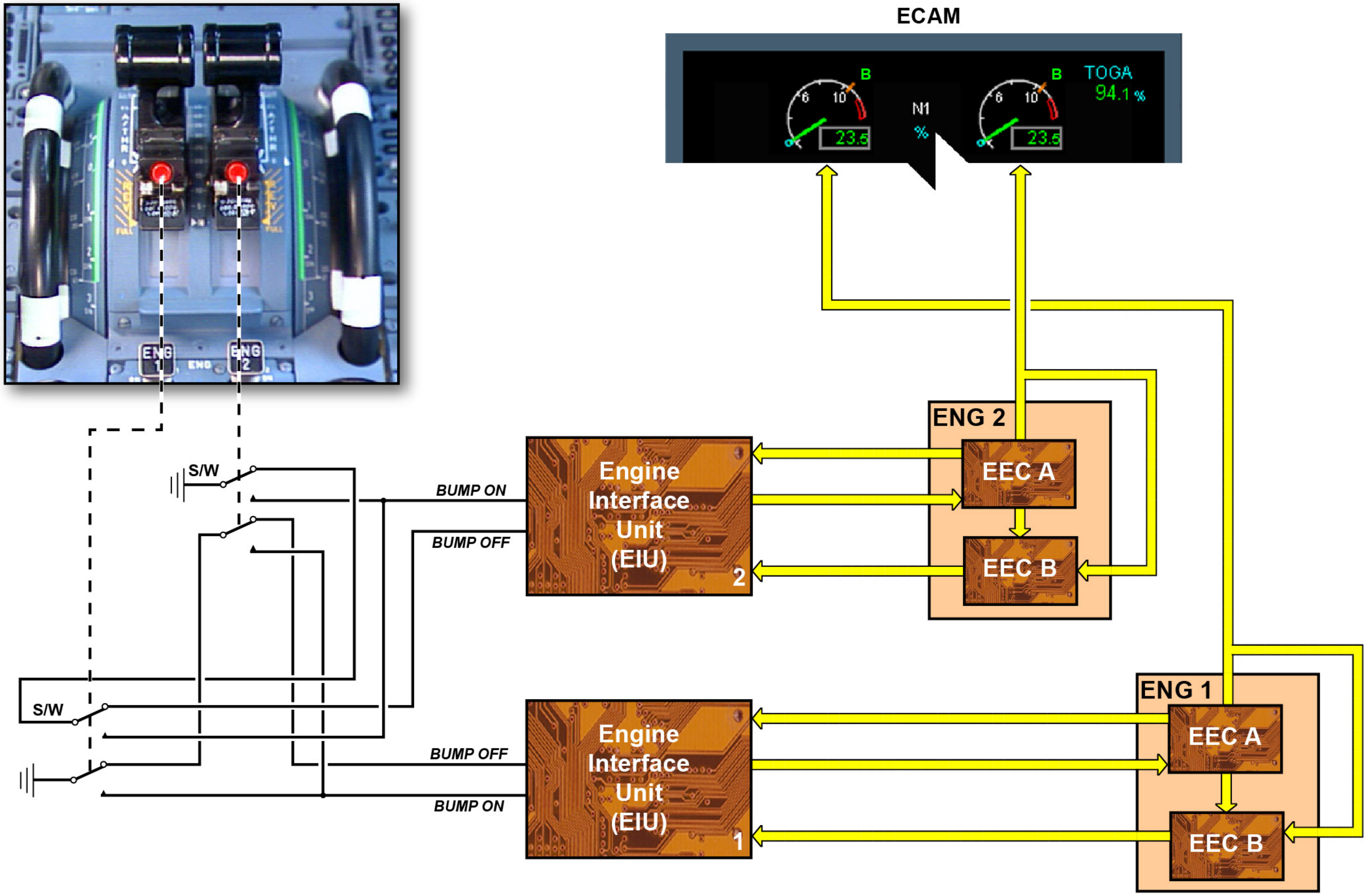
THROTTLE CONTROL SYSTEM D/O

BUMP FUNCTION (OPTION)

The BUMP function can be activated by the pilot to require an additional thrust during Take-Off and Go-Around due to environmental conditions (Take Off distance available, Maximum A/C payload, ambient temperature, ambient pressure).
This function is armed on ground by pressing one of the two "guarded" push buttons installed on the thrust levers.
Each push button position signal is transmitted to both EIU and then to the associated EECs.
The bump arming is displayed to the flight crew on the upper ECAM display (close to the N1 dial for each engine) through the display of a "B" character. In case of a failure of the Bump function following its activation, the "B" character is no longer displayed.
The Bump function can be armed on ground.
Once the bump is armed, and if the throttle lever is set above the FLEX/MCT position, Take-Off bump is active when all the specific following conditions are met:
- Throttle Lever in Take Off position,
- Engine core speed above 50%.

The bump function is disarmed (so deactivated):
- as soon as the thrust is reduced and the throttle lever is below FLEX/MCT position,
- or by pressing again the push button,
- or if the aircraft is confirmed on ground,
- or if the Master Lever is set to OFF.

There is no automatic reactivation in case of Go-Around selection.


ECAM
B
6
10
23.5
N1
%
B
6
10
23.5
TOGA
94.1 %
ENG 1
ENG 2
S/W
BUMP ON
BUMP OFF
S/W
BUMP OFF
BUMP ON
Engine
Interface
Unit
(EIU)
2
ENG 2
EEC A
EEC B
Engine
Interface
Unit
(EIU)
1
ENG 1
EEC A
EEC B

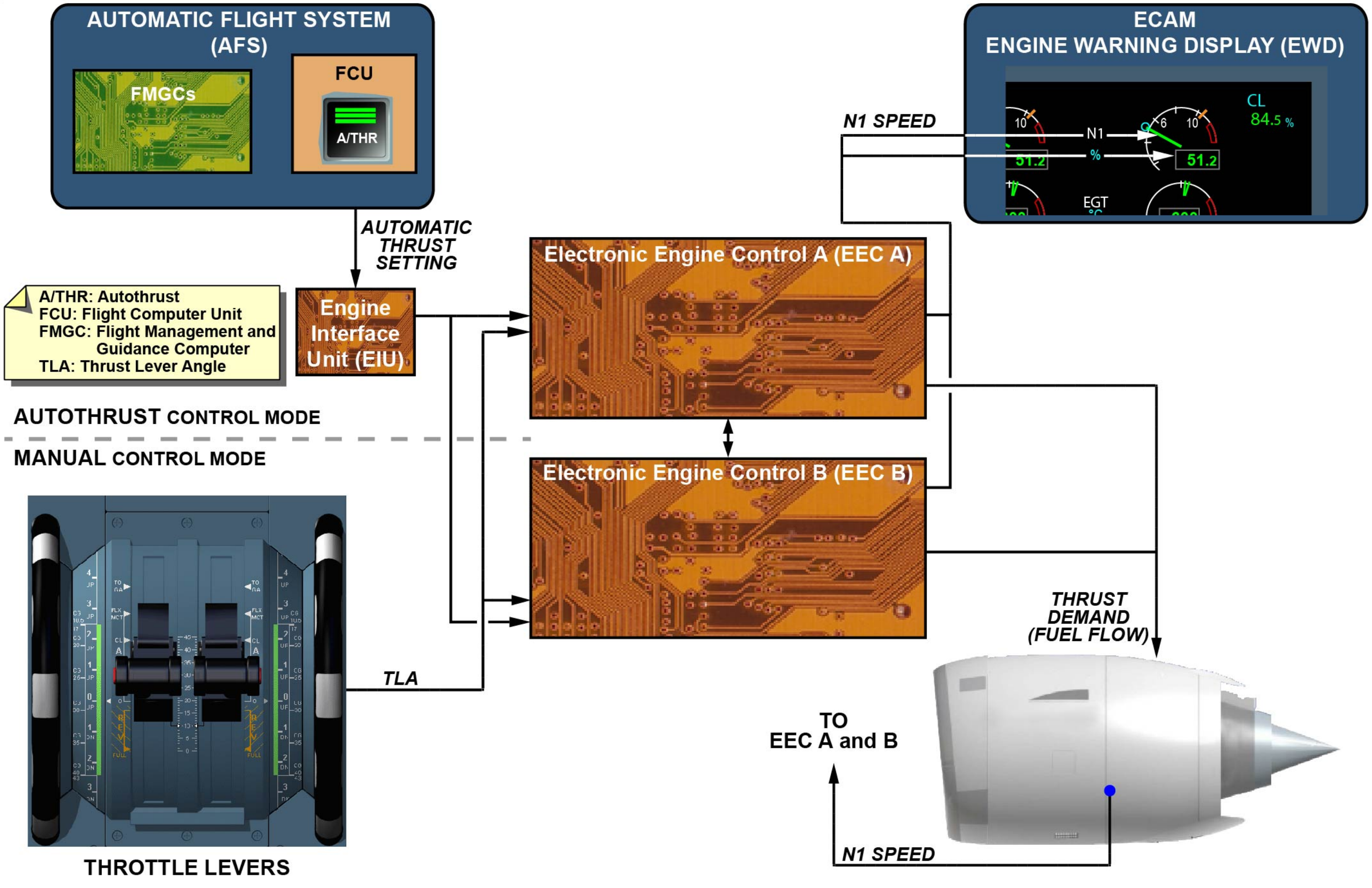
BUMP FUNCTION (OPTION)

ENGINE THRUST MANAGEMENT

GENERAL

The engine thrust is controlled under the management of the Electronic Engine Controllers (EEC A and B).
The engine thrust can be set:
- manually from the throttle control lever or,
- automatically from the Auto Flight System (AFS).

The engine thrust parameters are displayed on the ECAM.
The main thrust monitoring parameter is the N1 speed (LP shaft).
The main thrust demand parameter is the engine Fuel Flow (FF).
The actual N1 is the actual value given by the N1 speed sensor and is used as a reference for the engine thrust control loop.
This actual N1 is displayed in green on the N1 indicator and in percentage in the N1 box indicator.


AUTOMATIC FLIGHT SYSTEM (AFS)
FMGCs
FCU
A/THR
AUTOMATIC THRUST SETTING
Engine Interface Unit (EIU)
ECAM
ENGINE WARNING DISPLAY (EWD)
N1 SPEED
N1
%
CL
84.5 %
51.2
EGT
Electronic Engine Control A (EEC A)
Electronic Engine Control B (EEC B)
AUTOTHRUST CONTROL MODE
MANUAL CONTROL MODE
TLA
THRUST DEMAND (FUEL FLOW)
TO EEC A and B
N1 SPEED
THROTTLE LEVERS

A/THR: Autothrust
FCU: Flight Computer Unit
FMGC: Flight Management and Guidance Computer
TLA: Thrust Lever Angle

GENERAL

ENGINE THRUST MANAGEMENT

THRUST LIMIT MODE

The throttle levers are used as thrust limit mode selectors.
Depending on the throttle lever position, a thrust limit mode is selected and appears on the upper ECAM display.
If the throttle levers are set between two detent points, the upper detent will determine the thrust limit mode.
The thrust limit modes are:

- Climb (CL),
- Flexible Take Off or Maximum Continuous Thrust (FLX/MCT),
- Take Off-Go Around (TOGA),
- IDLE levels,
- Maximum Reverse (MREV).

The A/THR function is engaged manually when the A/THR P/B is selected or automatically at take-off power application. The A/THR function becomes active when the throttle levers are set to CLimb detent after take-off.
An additional Soft Go-Around (SGA) mode is available.
It is automatically selected if during approach, the TOGA detent is set and the thrust levers are then moved back to the FLX/MCT detent.

NOTE: Note:
- On the ground with the engines running, the displayed N1 rate limit corresponds to the TO/GA thrust limit whatever the thrust lever position is.
- On the ground with the engines running and if FLEX mode is selected, FLEX N1 is displayed whenever the thrust lever position is between IDLE and FLX/MCT.

N1 LIMIT

For each thrust limit mode selection, an N1 rating limit is computed by the EECs according to Thrust Lever Angle (TLA) and the air data parameters from the Air Data Inertial and Reference Units (ADIRUs).

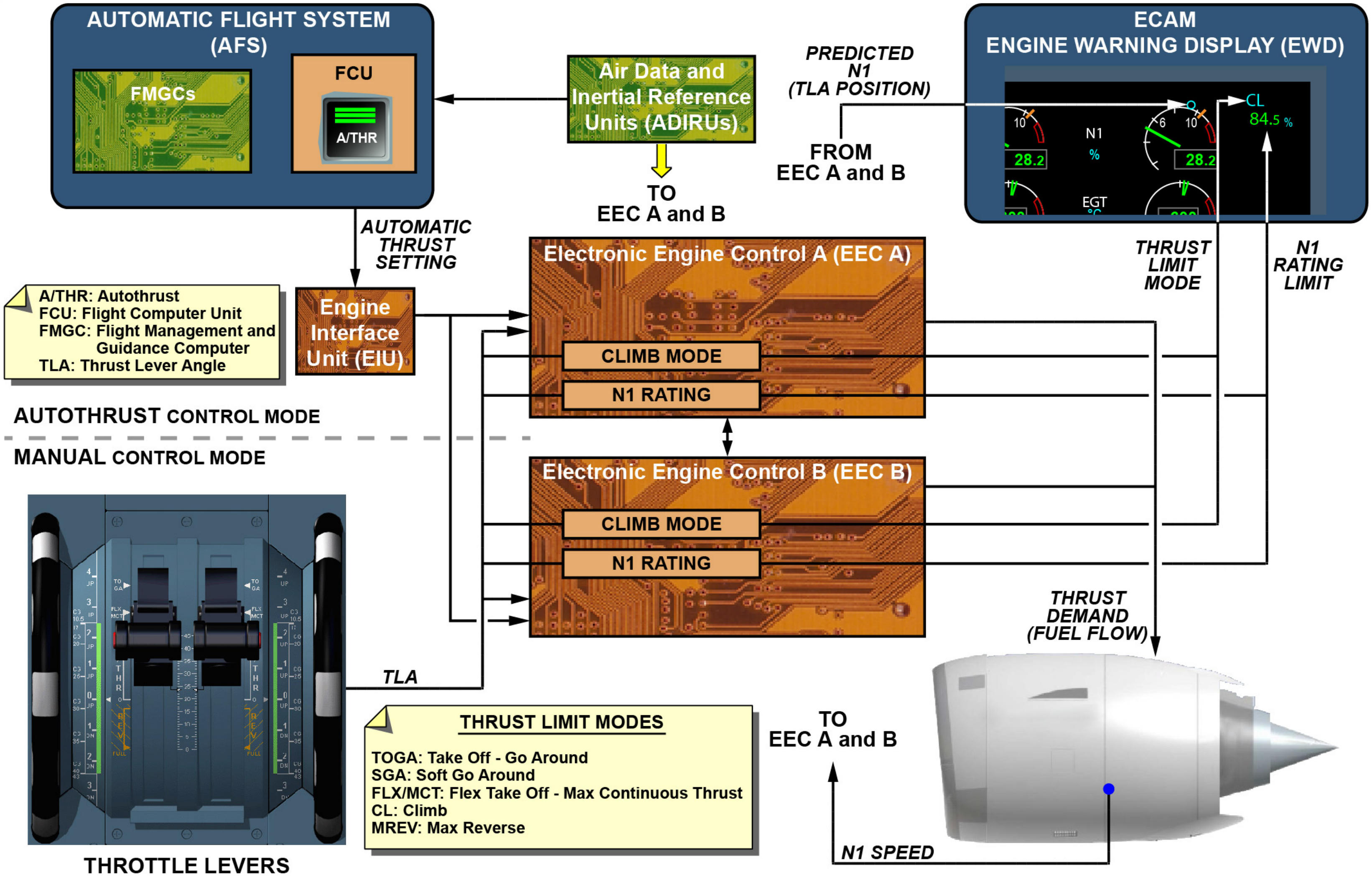
This indication is displayed in green on the upper ECAM display near the thrust limit mode indication.

PREDICTED N1(TLA POSITION)

The predicted maximum N1 is indicated by a blue circle on the N1 indicator and corresponds to the TLA position.

THRUST LIMIT MODE

TOGA, FLX, CL or MCT limit mode, selected by the position of whichever thrust lever is farther forward, is displayed in blue.


AUTOMATIC FLIGHT SYSTEM (AFS)
FMGCs
FCU
A/THR
Air Data and Inertial Reference Units (ADIRUs)
TO EEC A and B
PREDICTED N1 (TLA POSITION)
FROM EEC A and B
ECAM ENGINE WARNING DISPLAY (EWD)
CL
84.5 %
N1
%
28.2
28.2
EGT
AUTOMATIC THRUST SETTING
Engine Interface Unit (EIU)
Electronic Engine Control A (EEC A)
CLIMB MODE
N1 RATING
Electronic Engine Control B (EEC B)
CLIMB MODE
N1 RATING
THRUST LIMIT MODE
N1 RATING LIMIT
AUTOTHRUST CONTROL MODE
MANUAL CONTROL MODE
TLA
THROTTLE LEVERS
THRUST DEMAND (FUEL FLOW)
TO EEC A and B
N1 SPEED

A/THR: Autothrust
FCU: Flight Computer Unit
FMGC: Flight Management and Guidance Computer
TLA: Thrust Lever Angle

THRUST LIMIT MODES

TOGA: Take Off - Go Around
SGA: Soft Go Around
FLX/MCT: Flex Take Off - Max Continuous Thrust
CL: Climb
MREV: Max Reverse

THRUST LIMIT MODE - N1 LIMIT & PREDICTED N1

THRUST LIMIT MODE - N1 LIMIT ... THRUST LIMIT MODE

ENGINE THRUST MANAGEMENT

ACTUAL N1

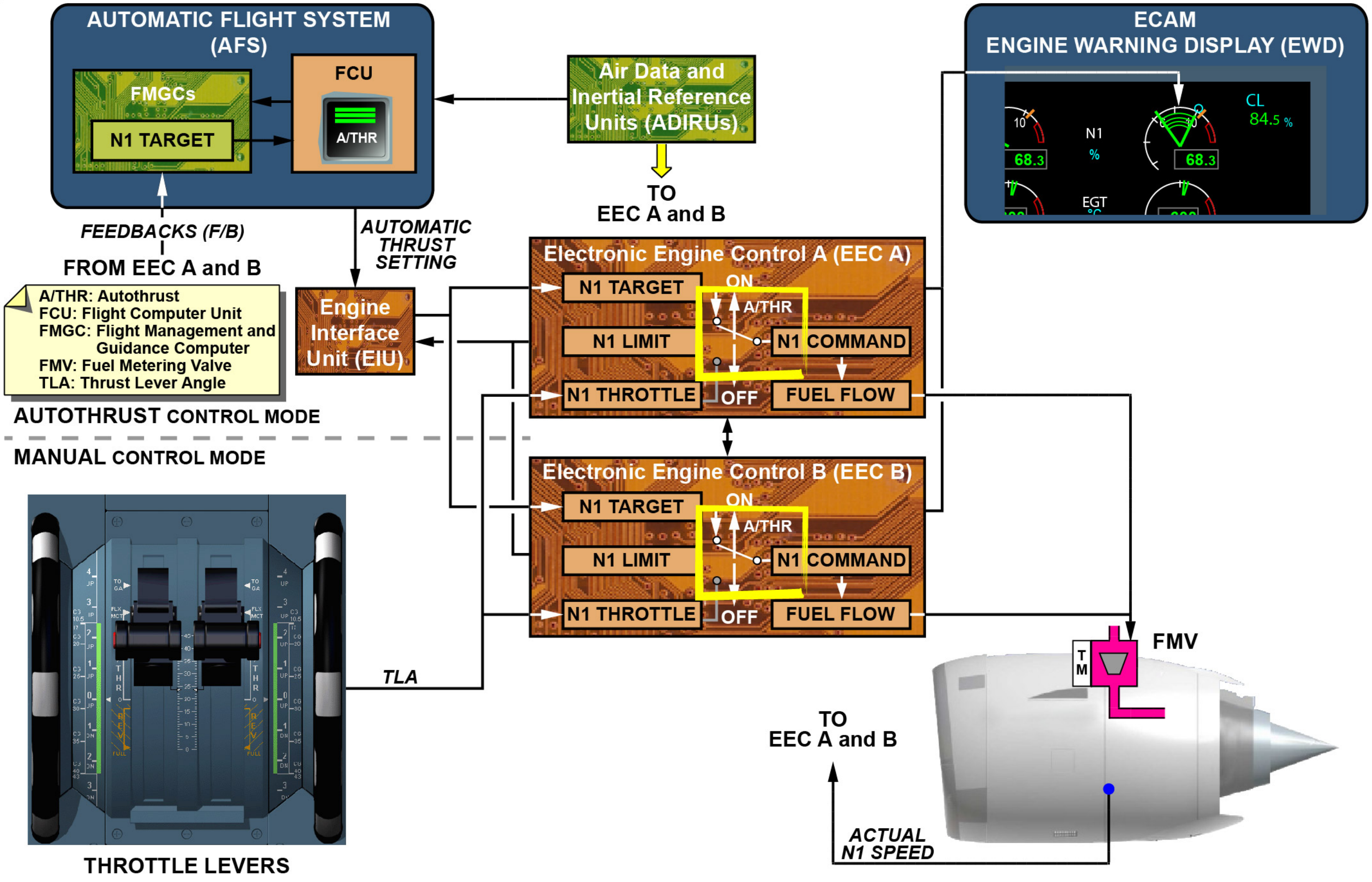
The actual N1 is the actual value given by the N1 speed sensor and is used as a reference for the engine thrust control loop.
This actual N1 is displayed in green on the N1 indicator.

N1 COMMAND

The N1 command, used to regulate the fuel flow, is the Flight Management and Guidance Computer (FMGC) N1 target when the A/THR function is active.
When the A/THR function is not active, the N1 command is the N1 corresponding to the TLA.

N1 TARGET

In A/THR mode, the FMGCs compute an N1 target according to the AFS command, the ADIRS data and the engine parameters and send this demand to the EECs.


AUTOMATIC FLIGHT SYSTEM (AFS)
FMGCs
N1 TARGET
FCU
A/THR
Air Data and Inertial Reference Units (ADIRUs)
TO EEC A and B
ECAM
ENGINE WARNING DISPLAY (EWD)
CL
84.5 %
N1
%
68.3
68.3
EGT
FEEDBACKS (F/B)
FROM EEC A and B
AUTOMATIC THRUST SETTING
Engine Interface Unit (EIU)
Electronic Engine Control A (EEC A)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
Electronic Engine Control B (EEC B)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
A/THR: Autothrust
FCU: Flight Computer Unit
FMGC: Flight Management and Guidance Computer
FMV: Fuel Metering Valve
TLA: Thrust Lever Angle
AUTOTHRUST CONTROL MODE
MANUAL CONTROL MODE
TLA
FMV
T M
TO EEC A and B
ACTUAL N1 SPEED
THROTTLE LEVERS
ACTUAL N1 - N1 COMMAND & N1 TARGET

ACTUAL N1 - N1 COMMAND & N1 TARGET

ENGINE THRUST MANAGEMENT

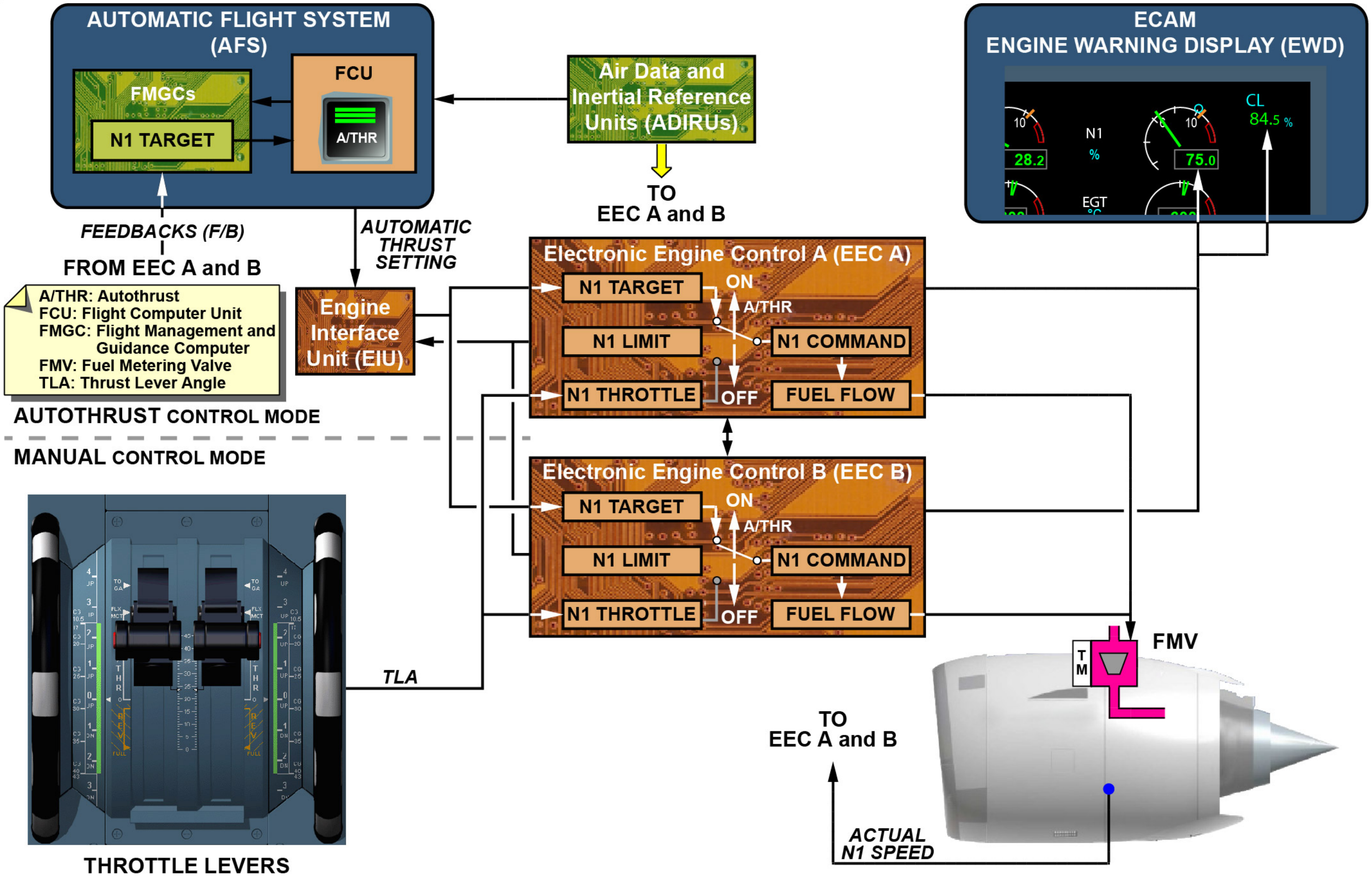
AUTOTHRUST CONTROL MODE

The A/THR function is engaged manually when the A/THR P/B is selected or automatically at take-off power application.

AUTOTHRUST ACTIVE

When engaged, the A/THR function becomes active when the throttle levers are set to CLimb detent after take-off.
The N1 command is the FMGC N1 target.
The A/THR function is normally active when the throttle levers are set between IDLE and CLimb (including CLimb).
The A/THR active range is extended to MCT in the case of single engine operation.
When the throttle levers are set between two detent points, the N1 command is limited by the throttle lever position.

NOTE: In case of Alpha Floor detection, the A/THR function becomes active automatically and the N1 target is to TOGA.


AUTOMATIC FLIGHT SYSTEM (AFS)
FMGCs
N1 TARGET
FCU
A/THR
Air Data and Inertial Reference Units (ADIRUs)
TO EEC A and B
ECAM
ENGINE WARNING DISPLAY (EWD)
10
N1
%
28.2
75.0
CL
84.5 %
EGT
°C
FEEDBACKS (F/B)
FROM EEC A and B
AUTOMATIC THRUST SETTING
A/THR: Autothrust
FCU: Flight Computer Unit
FMGC: Flight Management and Guidance Computer
FMV: Fuel Metering Valve
TLA: Thrust Lever Angle
Engine Interface Unit (EIU)
Electronic Engine Control A (EEC A)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
AUTOTHRUST CONTROL MODE
MANUAL CONTROL MODE
Electronic Engine Control B (EEC B)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
TLA
FMV
T
M
TO EEC A and B
ACTUAL N1 SPEED
THROTTLE LEVERS

AUTOTHRUST CONTROL MODE - AUTOTHRUST ACTIVE

AUTOTHRUST CONTROL MODE - AUTOTHRUST ACTIVE

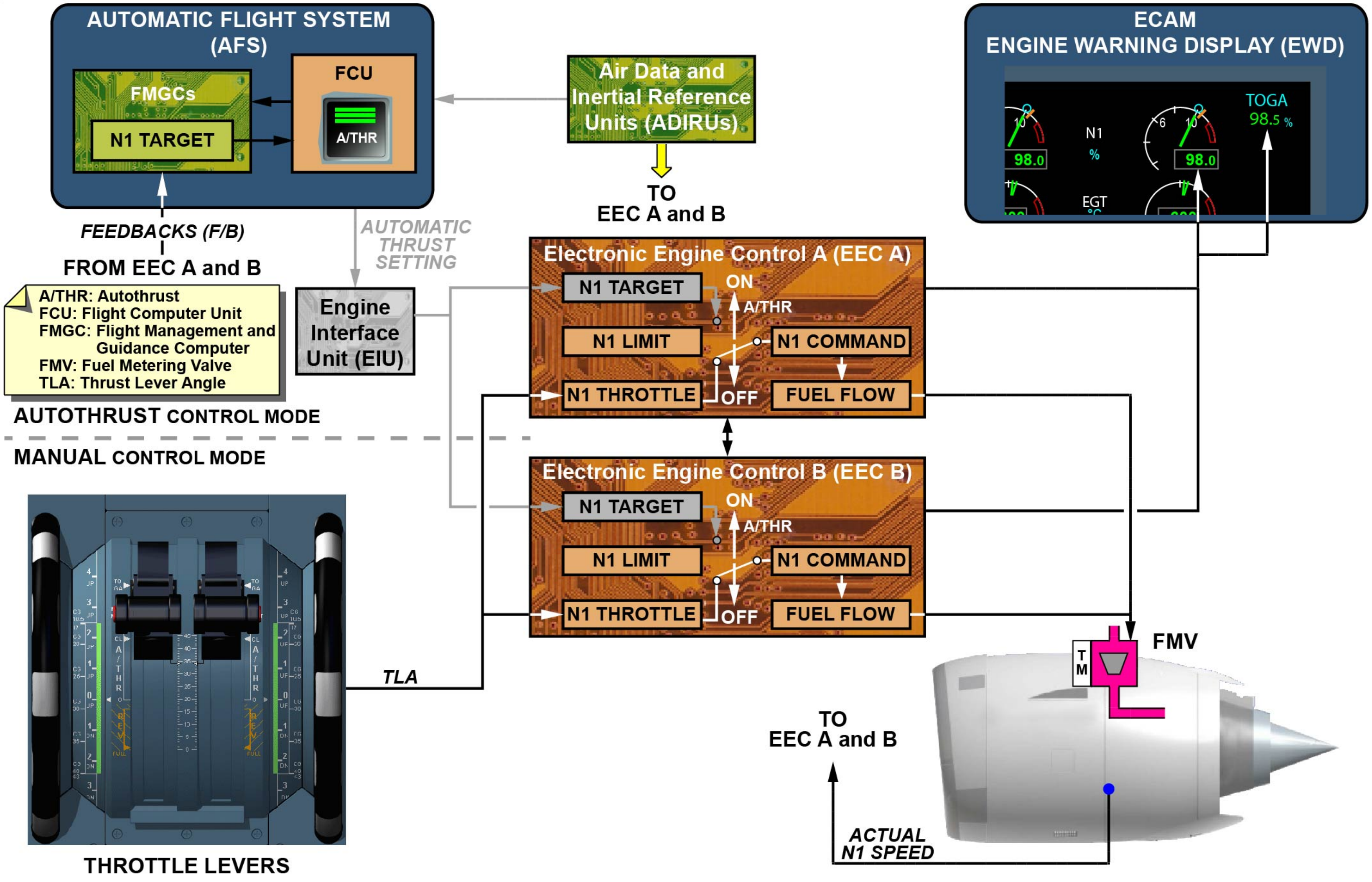
ENGINE THRUST MANAGEMENT

AUTOTHRUST CONTROL MODE (continued)

AUTOTHRUST NOT ACTIVE

When engaged, the A/THR function becomes inactive when the throttle levers are set above CLimb with both engines running.
In this case, the N1 command corresponds to the N1 throttle (TLA).

NOTE: The A/THR function is inactive above MCT in case of single engine operation.
The A/THR function is disengaged when the throttle levers are set at IDLE stop.


AUTOMATIC FLIGHT SYSTEM (AFS)
FMGCs
N1 TARGET
FCU
A/THR
FEEDBACKS (F/B)
FROM EEC A and B
AUTOMATIC THRUST SETTING
Air Data and Inertial Reference Units (ADIRUs)
TO EEC A and B
ECAM ENGINE WARNING DISPLAY (EWD)
TOGA
98.5 %
N1
%
98.0
98.0
EGT
Engine Interface Unit (EIU)
Electronic Engine Control A (EEC A)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
AUTOTHRUST CONTROL MODE
MANUAL CONTROL MODE
Electronic Engine Control B (EEC B)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
TLA
FMV
T M
TO EEC A and B
ACTUAL N1 SPEED
THROTTLE LEVERS

A/THR: Autothrust
FCU: Flight Computer Unit
FMGC: Flight Management and Guidance Computer
FMV: Fuel Metering Valve
TLA: Thrust Lever Angle

AUTOTHRUST CONTROL MODE - AUTOTHRUST NOT ACTIVE

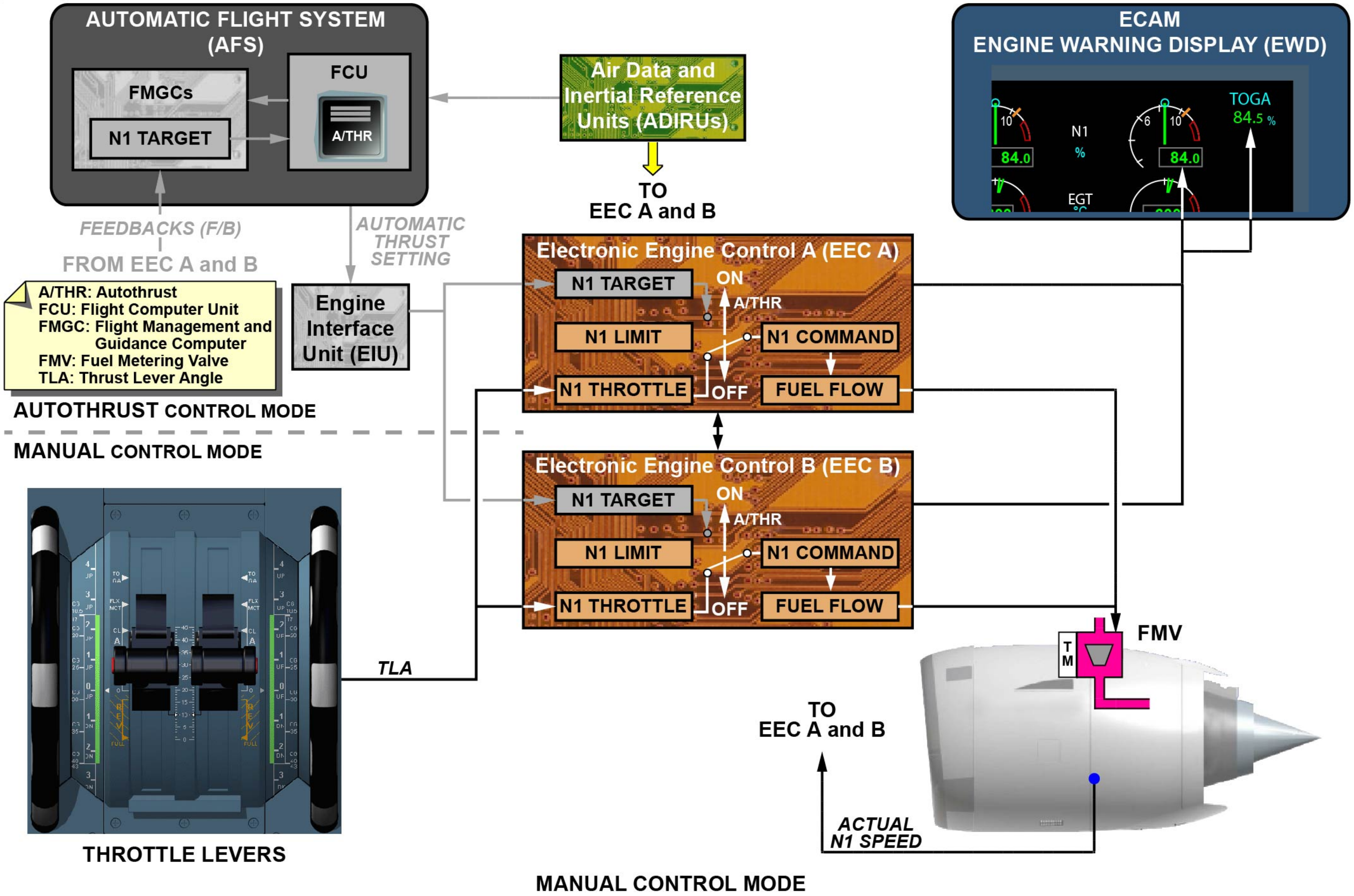
AUTOTHRUST CONTROL MODE - AUTOTHRUST NOT ACTIVE

ENGINE THRUST MANAGEMENT

AUTOTHRUST CONTROL MODE (continued)

MANUAL CONTROL MODE

The engines are in manual control mode when the A/THR function is not engaged, or engaged and not active (throttle levers not in the A/THR operating range and no Alpha Floor detected).


AUTOMATIC FLIGHT SYSTEM (AFS)
FMGCs
N1 TARGET
FCU
A/THR
Air Data and Inertial Reference Units (ADIRUs)
TO EEC A and B
ECAM
ENGINE WARNING DISPLAY (EWD)
N1
%
EGT
TOGA
84.5 %
84.0
84.0
FEEDBACKS (F/B)
FROM EEC A and B
AUTOMATIC THRUST SETTING
Engine Interface Unit (EIU)
A/THR: Autothrust
FCU: Flight Computer Unit
FMGC: Flight Management and Guidance Computer
FMV: Fuel Metering Valve
TLA: Thrust Lever Angle
AUTOTHRUST CONTROL MODE
MANUAL CONTROL MODE
Electronic Engine Control A (EEC A)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
Electronic Engine Control B (EEC B)
N1 TARGET
ON
A/THR
N1 LIMIT
N1 COMMAND
N1 THROTTLE
OFF
FUEL FLOW
TLA
THROTTLE LEVERS
FMV
T
M
TO EEC A and B
ACTUAL N1 SPEED
MANUAL CONTROL MODE

AUTOTHRUST CONTROL MODE - MANUAL CONTROL MODE

ENGINE THRUST MANAGEMENT

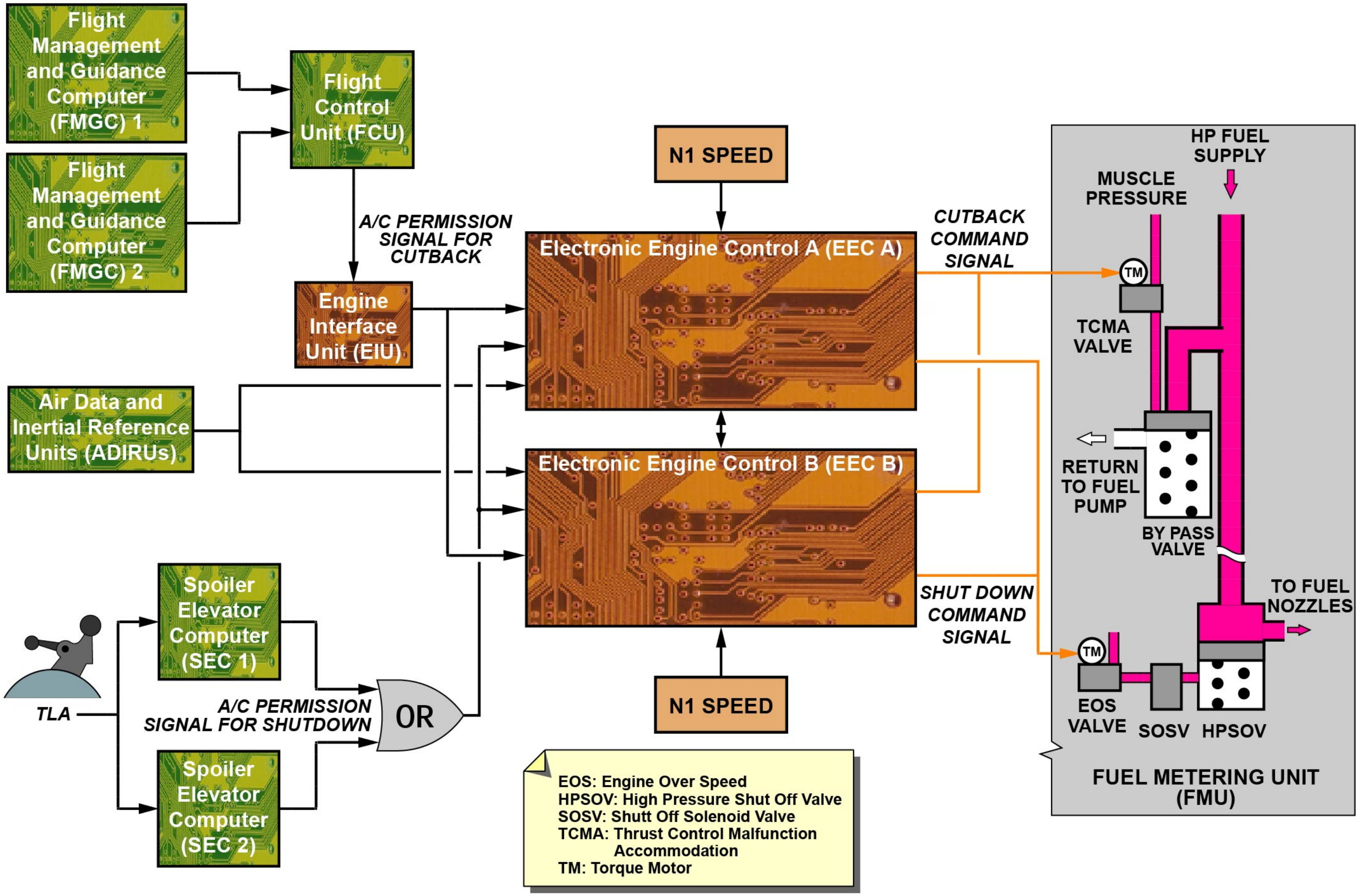
THRUST CONTROL MALFUNCTION ACCOMMODATION

The intent of Thrust Control Malfunction Accommodation (TCMA) logic is to identify if the engine is not responding the throttle command and take mitigating action if required.
In flight, mainly during flare and landing phases, if the engine control is affected (engine thrust is higher than the throttle command), a TCMA cutback sequence is applied.
On ground, if the engine control is affected (engine thrust does not response to throttle command, for instance when idle is requested during a rejected take-off), a TCMA shutdown sequence is applied.
The EEC shall enable the fuel cutback function when:
- Fan speed (N1) is greater than Thrust Control Malfunction (TCM) threshold,
- Pressure altitude below 15,000 ft,
- Mach number less than 0.40.

NOTE: The EECs use TCMA logic data from FMGCs to Flight Control Unit (FCU) to automatically reduce engine thrust (cutback) during flare.

The EEC shall enable the fuel shutoff function when:
- Fan speed (N1) is greater than TCMA threshold or TCMA cutback already applied,
- Pressure altitude below 15,000 ft,
- Mach number less than 0.40,
- The EEC receives a valid "aircraft on-ground" signal,
- Throttle is at or below idle.

A fuel cutback is achieved by a fuel flow reduction via the TCMA Torque Motor (TM) that opens the Bypass valve in order to decrease the fuel flow and the engine thrust to a pre-set value.
A fuel shutdown is achieved by the control of the Hugh Pressure Shut-Off Valve (HPSOV) via the Engine Over Speed (EOS) shutdown hardware (EOSV TM and Shut Off Solenoid Valve (SOSV)) to the close position in order to stop the fuel flow and shut down the engine.


Flight Management and Guidance Computer (FMGC) 1
Flight Management and Guidance Computer (FMGC) 2
Flight Control Unit (FCU)
A/C PERMISSION SIGNAL FOR CUTBACK
Engine Interface Unit (EIU)
Air Data and Inertial Reference Units (ADIRUs)
N1 SPEED
Electronic Engine Control A (EEC A)
Electronic Engine Control B (EEC B)
N1 SPEED
CUTBACK COMMAND SIGNAL
SHUT DOWN COMMAND SIGNAL
Spoiler Elevator Computer (SEC 1)
Spoiler Elevator Computer (SEC 2)
TLA
A/C PERMISSION SIGNAL FOR SHUTDOWN
OR
HP FUEL SUPPLY
MUSCLE PRESSURE
TM
TCMA VALVE
RETURN TO FUEL PUMP
BY PASS VALVE
TO FUEL NOZZLES
TM
EOS VALVE
SOSV
HPSOV
FUEL METERING UNIT (FMU)

EOS: Engine Over Speed
HPSOV: High Pressure Shut Off Valve
SOSV: Shutt Off Solenoid Valve
TCMA: Thrust Control Malfunction Accommodation
TM: Torque Motor

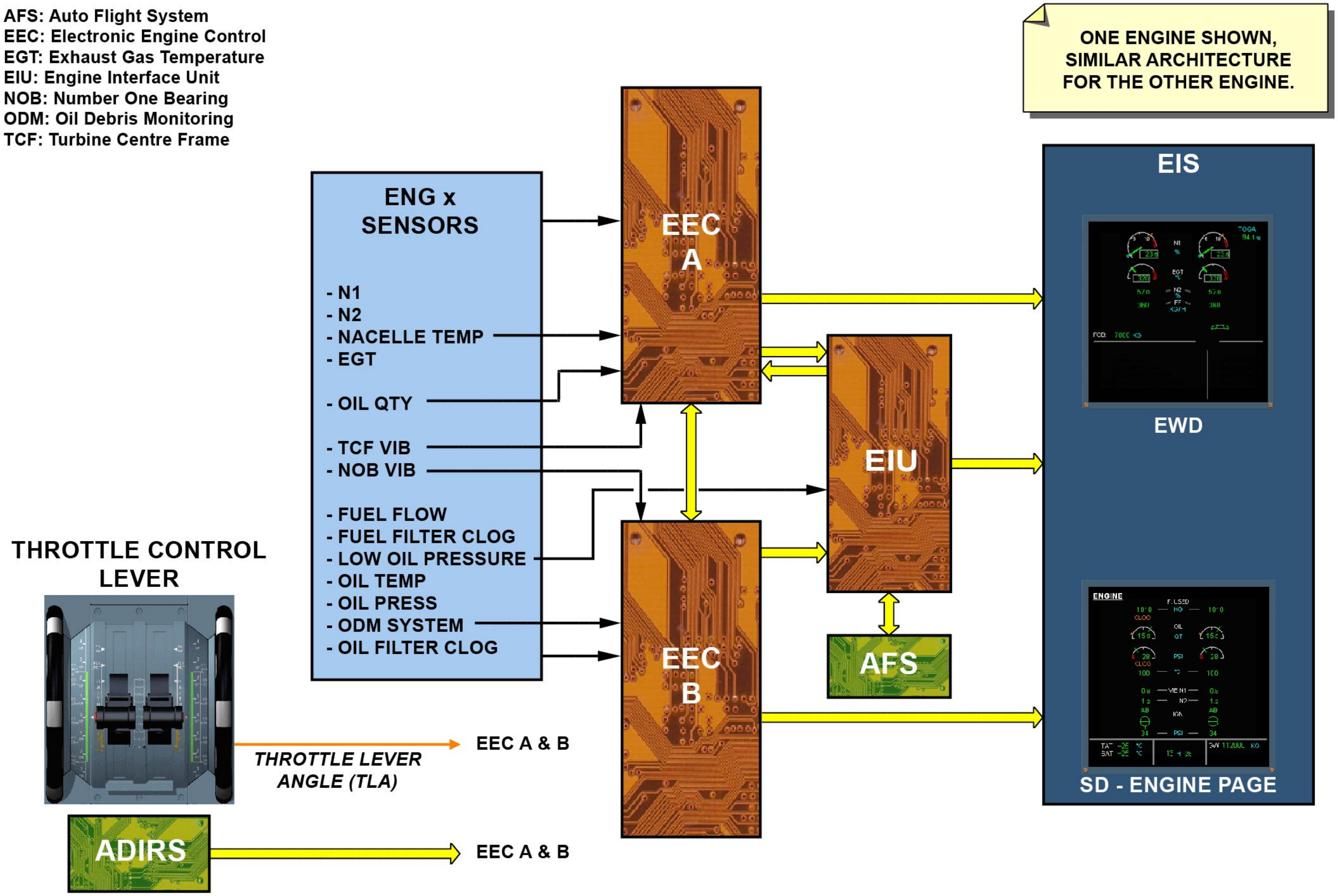
THRUST CONTROL MALFUNCTION ACCOMMODATION

ENGINE MONITORING D/O

INDICATING

The engine indicating system has sensors that measure some engine parameters. These parameters are sent to the Electronic Engine Control (EEC) A and B for cross-check, computation and transmission. They are sent to the Electronic Instrument System (EIS) for display on the EWD (primary parameters) and on the SD-ENGINE page (secondary parameters).
Some parameters are also used, in conjunction with inputs from the ADIRS, to control and monitor the engine thrust with:
- the Throttle Lever Angle (TLA) position in manual thrust control mode or
- the Auto Flight System (AFS) inputs via the Engine Interface Unit (EIU) in auto thrust control mode.

AFS: Auto Flight System
EEC: Electronic Engine Control
EGT: Exhaust Gas Temperature
EIU: Engine Interface Unit
NOB: Number One Bearing
ODM: Oil Debris Monitoring
TCF: Turbine Centre Frame


ONE ENGINE SHOWN, SIMILAR ARCHITECTURE FOR THE OTHER ENGINE.

ENG x SENSORS
- N1
- N2
- NACELLE TEMP
- EGT
- OIL QTY
- TCF VIB
- NOB VIB
- FUEL FLOW
- FUEL FILTER CLOG
- LOW OIL PRESSURE
- OIL TEMP
- OIL PRESS
- ODM SYSTEM
- OIL FILTER CLOG
EEC A
EEC B
EIU
AFS
EIS
EWD
SD - ENGINE PAGE
THROTTLE CONTROL LEVER
THROTTLE LEVER ANGLE (TLA)
EEC A & B
ADIRS
EEC A & B

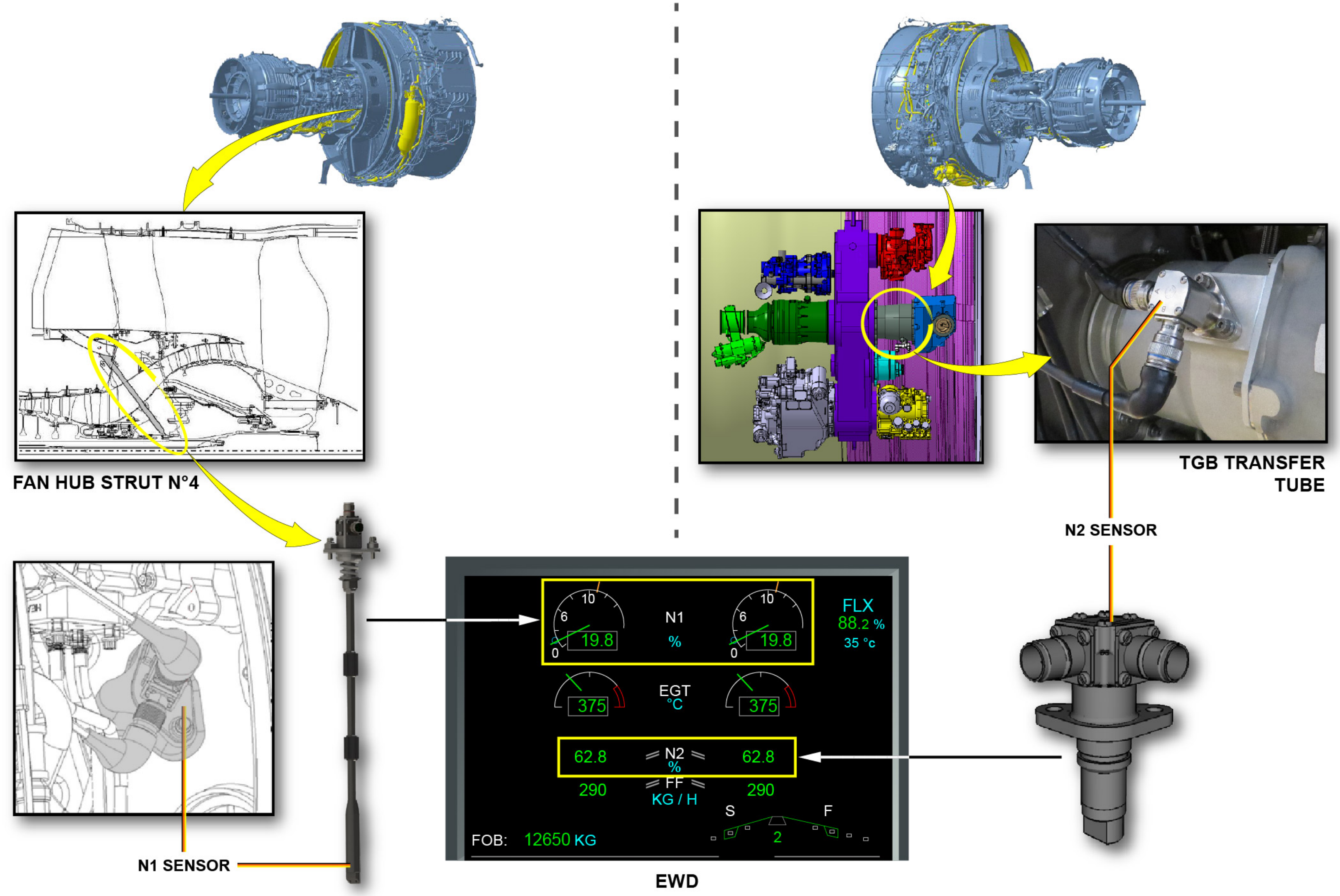
INDICATING

ENGINE MONITORING D/O

PRIMARY PARAMETERS

ROTATIONAL SPEED PARAMETERS DESCRIPTION

The N1 speed sensor provides a redundant Low Pressure (LP) rotor speed (N1) signal to the EECs. The indication is shown in the ECAM EWD by a needle and a N1 digital indication display. The sensor is mounted into a sleeve, inside Fan Hub N°4 strut, and then into a guide.
The N2 speed sensor provides a redundant High Pressure (HP) rotor speed (N2) to the EECs. The N2 rotational speed is indicated in the ECAM EWD by digits. The sensor is installed on the transfer tube between the Transfer Gear Box (TGB) and the Accessory Gear Box (AGB).
Both the N1 and N2 speed sensors are dual channel magnetic speed sensors and transmit the corresponding signals to the EEC A and B for engine thrust control and vibration monitoring. The N1 once-per-revolution signal (angular position) is also used for the fan trim balancing during maintenance.
The N1 and N2 sensors are Line Replaceable Units (LRU).


FAN HUB STRUT N°4
TGB TRANSFER TUBE
N2 SENSOR
N1 SENSOR
EWD
10
6
0
N1
%
19.8
19.8
FLX
88.2 %
35 °c
EGT
°C
375
375
62.8
N2
%
62.8
290
FF
KG / H
290
S
F
2
FOB: 12650 KG

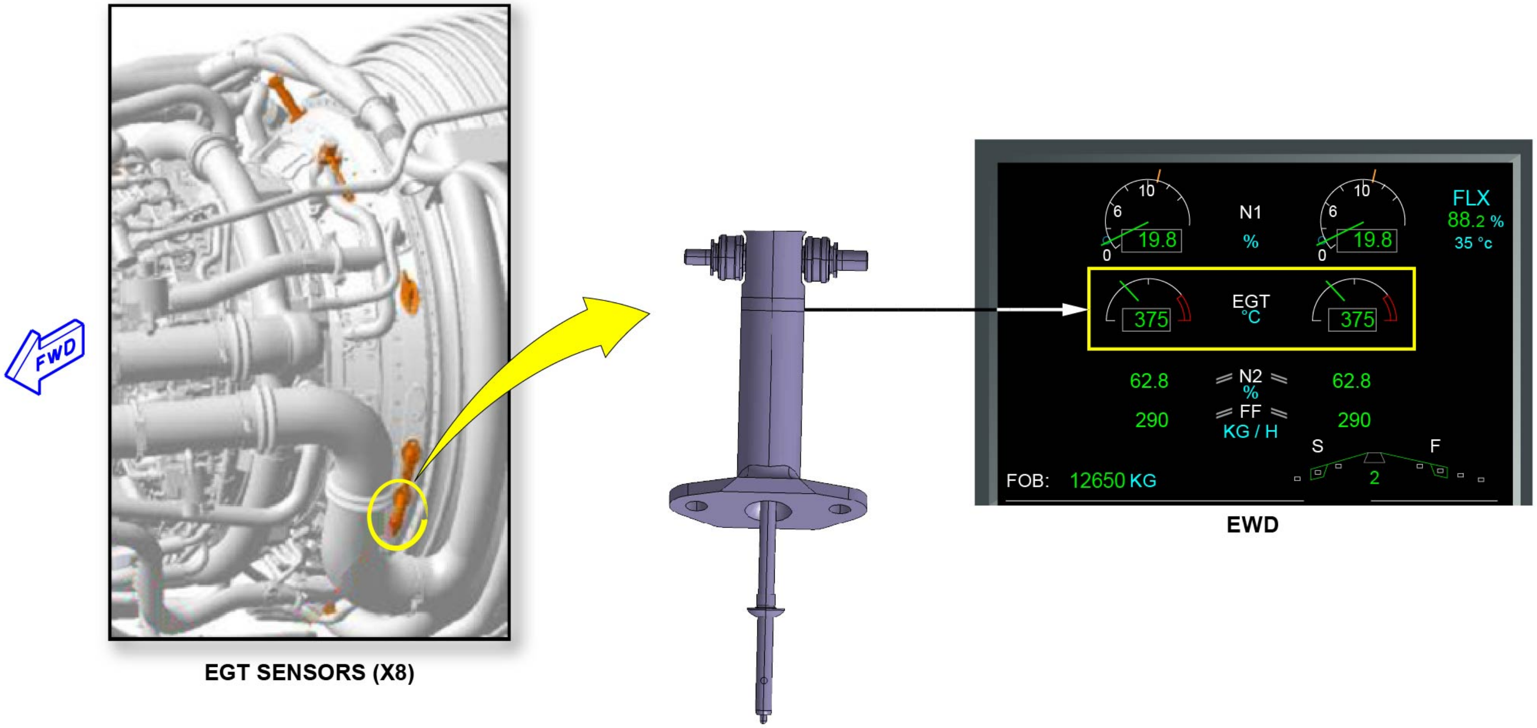
PRIMARY PARAMETERS - ROTATIONAL SPEED PARAMETERS DESCRIPTION

ENGINE MONITORING D/O

PRIMARY PARAMETERS (continued)

EGT PARAMETERS

The calculated EGT value is displayed on the ECAM EWD by a needle and an EGT digital indication.
The EGT sensors are also used to monitor the engine start, relight and operation and to determinate the EGT margin.
The EGT sensors (also named T48 sensors) are LRUs and they are identical and fully interchangeable.


FWD
EGT SENSORS (X8)
10
6
0
19.8
N1
%
10
6
0
19.8
FLX
88.2 %
35 °c
375
EGT
°C
375
62.8
N2
%
62.8
290
FF
KG / H
290
S
F
FOB: 12650 KG
2
EWD

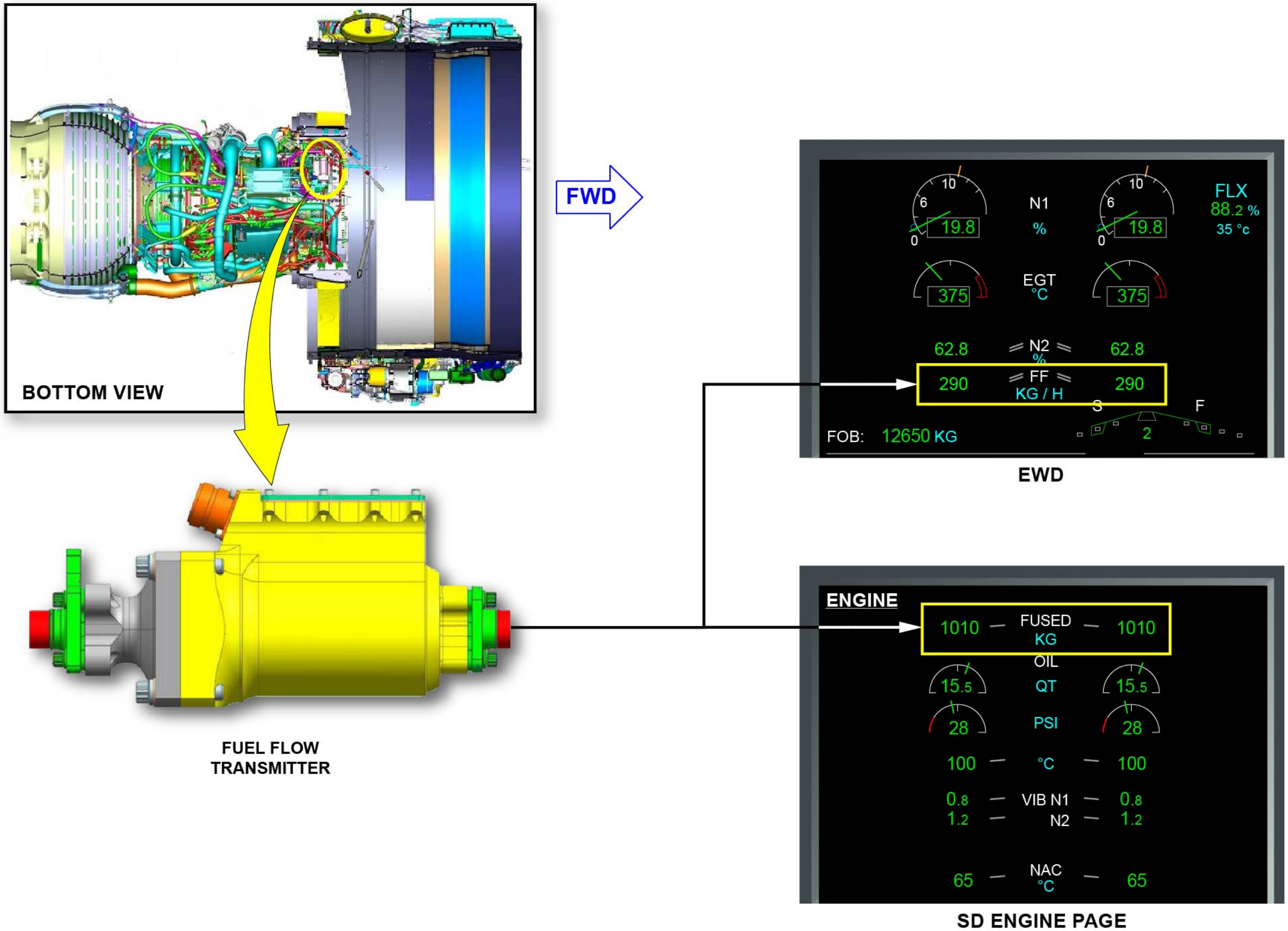
PRIMARY PARAMETERS - EGT PARAMETERS

ENGINE MONITORING D/O

PRIMARY PARAMETERS (continued)

FUEL PARAMETERS DESCRIPTION

The Fuel Flow Meter (FFM) is installed in line between the Fuel Metering Unit (FMU) discharge and the Split Control Unit / Servo Valve Assembly (SCU/SVA). The FFM is a passive, time-based pulse output transmitter; it is installed on the engine core at the 5 o'clock position.
It measures the mass flow rate of metered fuel supplied to the combustor and sends it to the EECs.
The fuel used value is computed by the EIU from the fuel flow value sent by the EECs. For each engine, it is computed from the engine start to the engine shutdown.
The FWC also monitors both engine Fuel Flow (FF) and trigger the alert in case of one engine showing abnormally high value compared to the other one.
The FFM is an LRU.


BOTTOM VIEW
FWD
FUEL FLOW TRANSMITTER
10
6
0
19.8
N1
%
FLX
88.2 %
35 °c
375
EGT
°C
62.8
N2
%
290
FF
KG / H
S
F
FOB: 12650 KG
2
EWD
ENGINE
1010
FUSED
KG
OIL
15.5
QT
28
PSI
100
°C
0.8
1.2
VIB N1
N2
65
NAC
°C
SD ENGINE PAGE

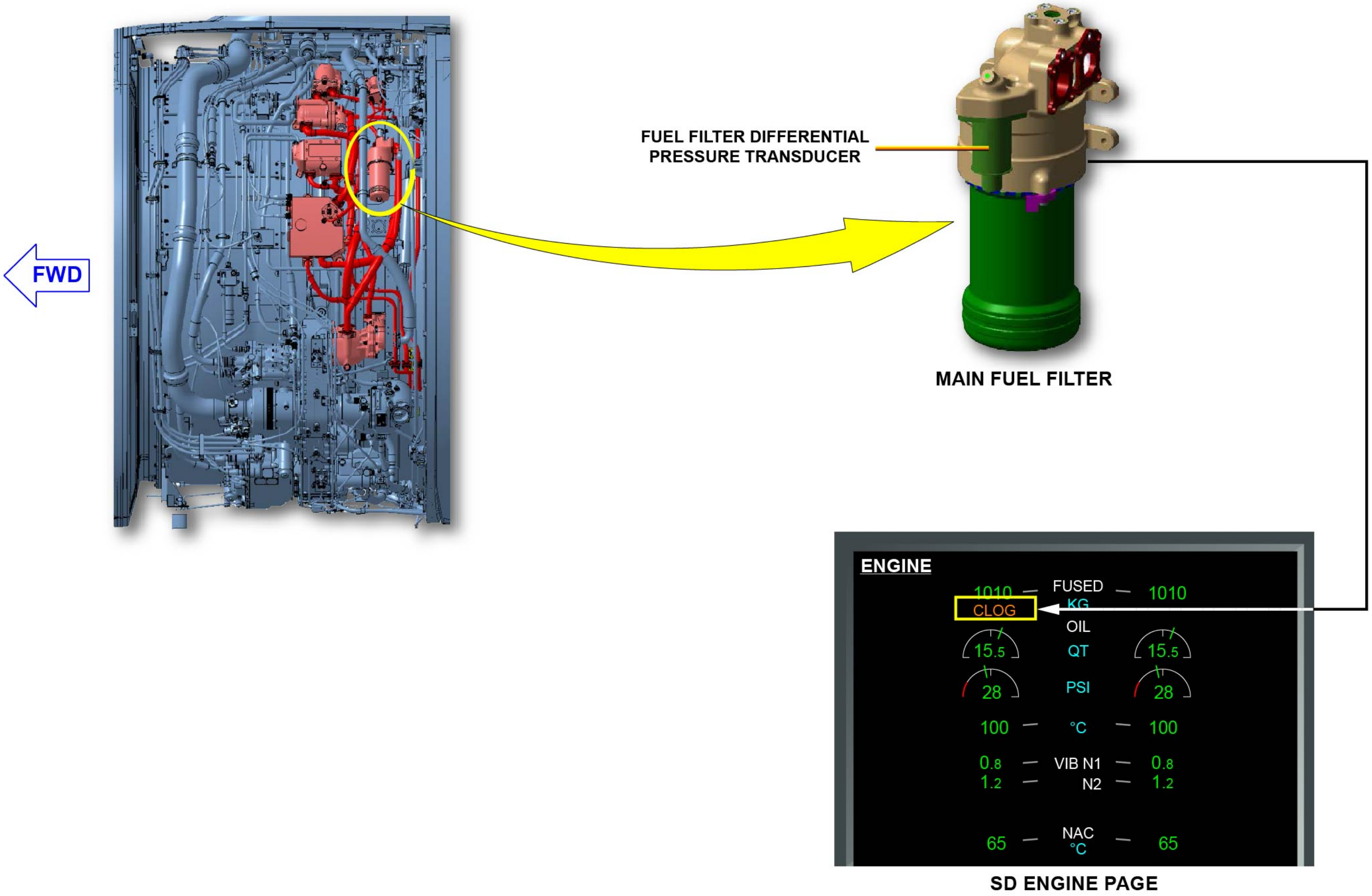
PRIMARY PARAMETERS - FUEL PARAMETERS DESCRIPTION

ENGINE MONITORING D/O

SECONDARY PARAMETERS

FUEL PARAMETERS DESCRIPTION

The FFDP sensor is an LRU.


FWD
FUEL FILTER DIFFERENTIAL
PRESSURE TRANSDUCER
MAIN FUEL FILTER
ENGINE
1010
FUSED
KG
1010
CLOG
OIL
15.5
QT
15.5
28
PSI
28
100
°C
100
0.8
VIB N1
0.8
1.2
N2
1.2
65
NAC
°C
65
SD ENGINE PAGE

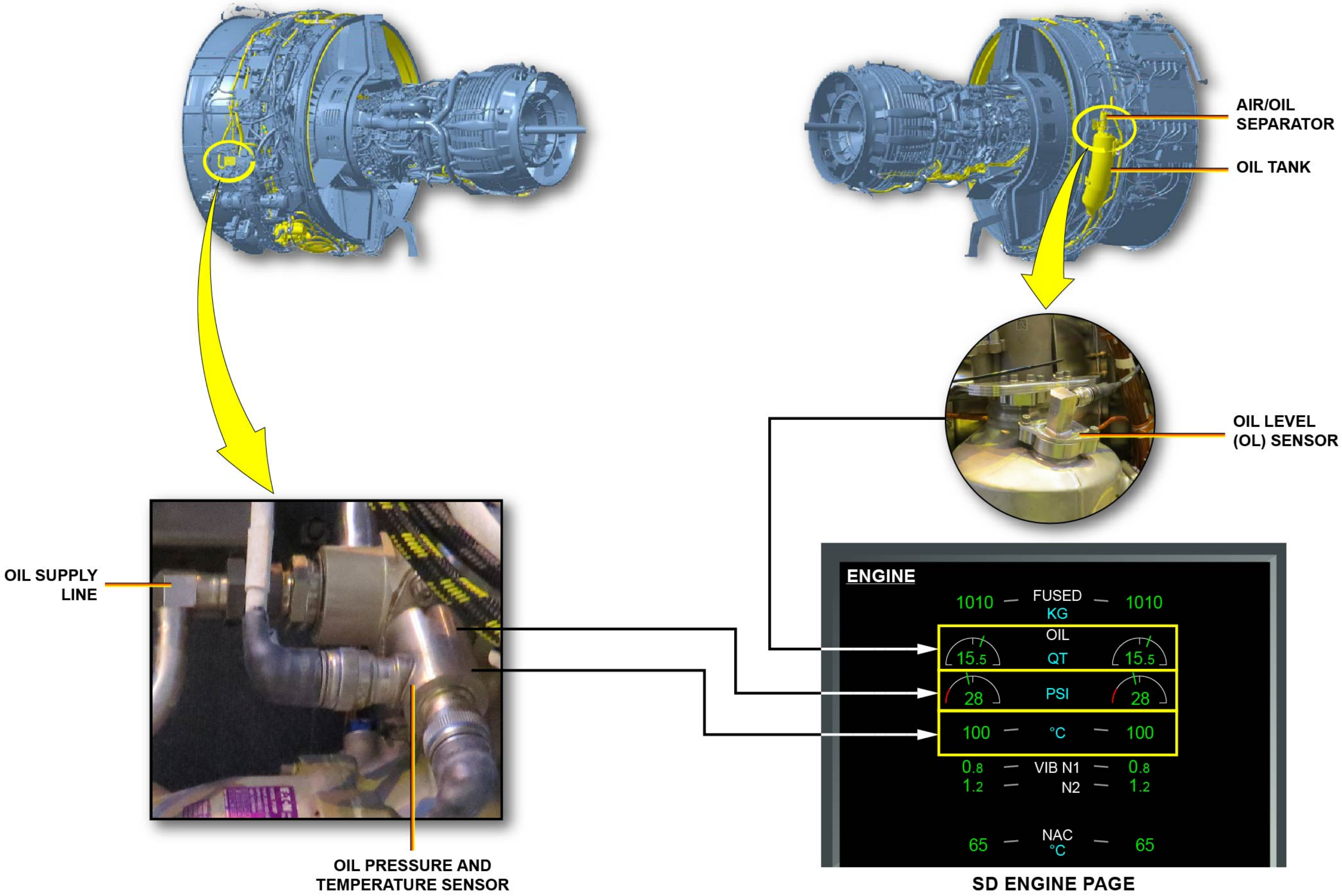
SECONDARY PARAMETERS - FUEL PARAMETERS DESCRIPTION

ENGINE MONITORING D/O

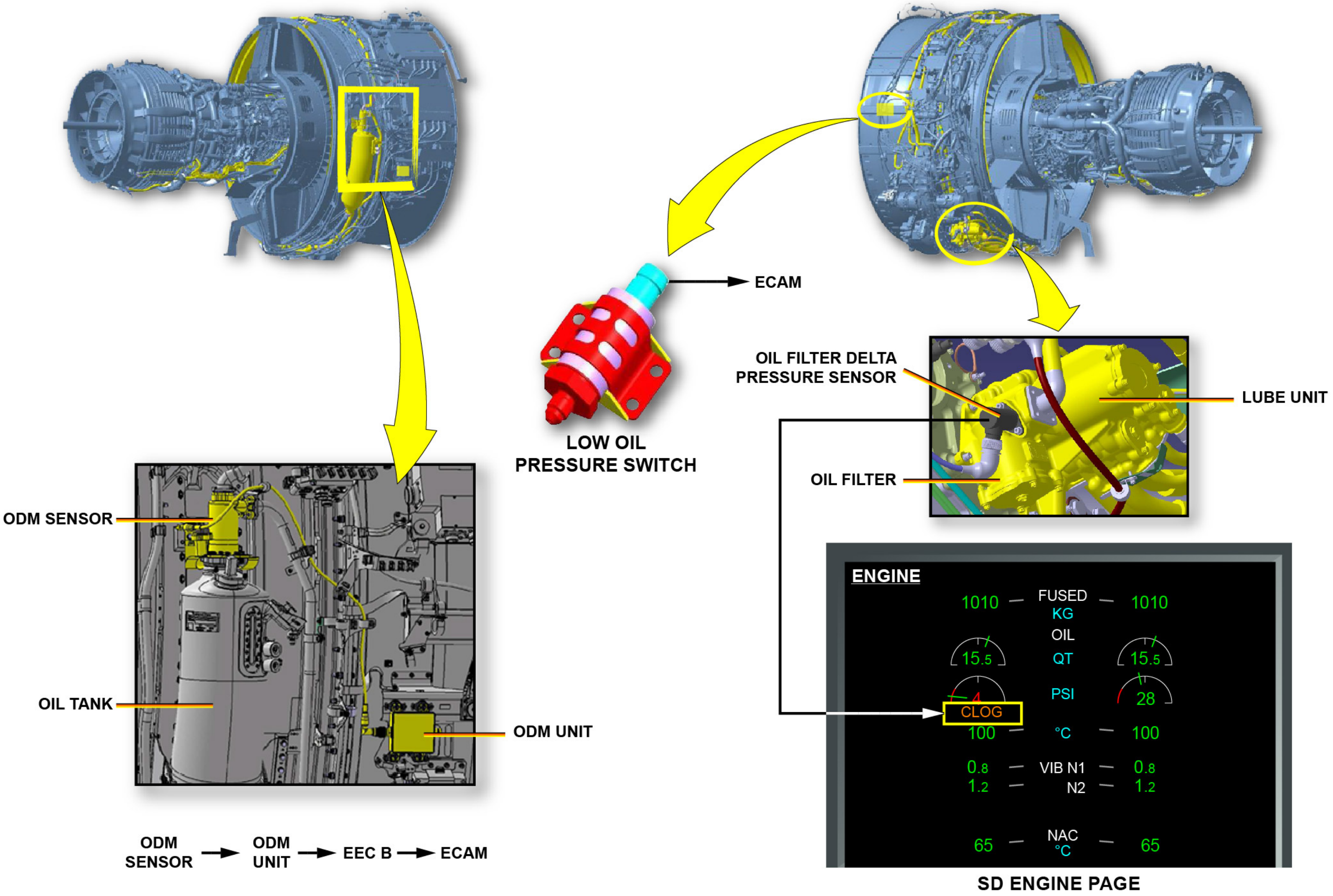
SECONDARY PARAMETERS (continued)

OIL PARAMETERS DESCRIPTION

The Oil Level Sensor (OLS) is mounted on top of the oil tank located on the right-hand side of the Fan Case at the 4 o'clock position. It is a single channel sensor of reed switches type.
The EEC A receives the information and shares it with EEC B for display on ECAM SD ENGINE page.
The OLS is an LRU.
The OPT sensor is mounted on the oil supply line at the AGB inlet. It is a dual channel sensor which sends the signals to both EECs for monitoring and display on ECAM SD ENGINE page.
The OPT sensor is an LRU.
The OFDP sensor is an LRU.
The LOP switch is an LRU.
The ODM sensor and ODMU are LRUs.


AIR/OIL SEPARATOR
OIL TANK
OIL LEVEL (OL) SENSOR
OIL SUPPLY LINE
OIL PRESSURE AND TEMPERATURE SENSOR
ENGINE
1010
FUSED KG
1010
OIL
15.5
QT
15.5
28
PSI
28
100
°C
100
0.8
VIB N1
0.8
1.2
N2
1.2
65
NAC °C
65
SD ENGINE PAGE

SECONDARY PARAMETERS - OIL PARAMETERS DESCRIPTION


ECAM
LOW OIL
PRESSURE SWITCH
OIL FILTER DELTA
PRESSURE SENSOR
LUBE UNIT
OIL FILTER
ODM SENSOR
OIL TANK
ODM UNIT
ENGINE
1010
FUSED
KG
1010
OIL
15.5
QT
15.5
4
PSI
28
CLOG
100
°C
100
0.8
VIB N1
0.8
1.2
N2
1.2
65
NAC
°C
65
ODM
SENSOR
ODM
UNIT
EEC B
ECAM
SD ENGINE PAGE

SECONDARY PARAMETERS - OIL PARAMETERS DESCRIPTION

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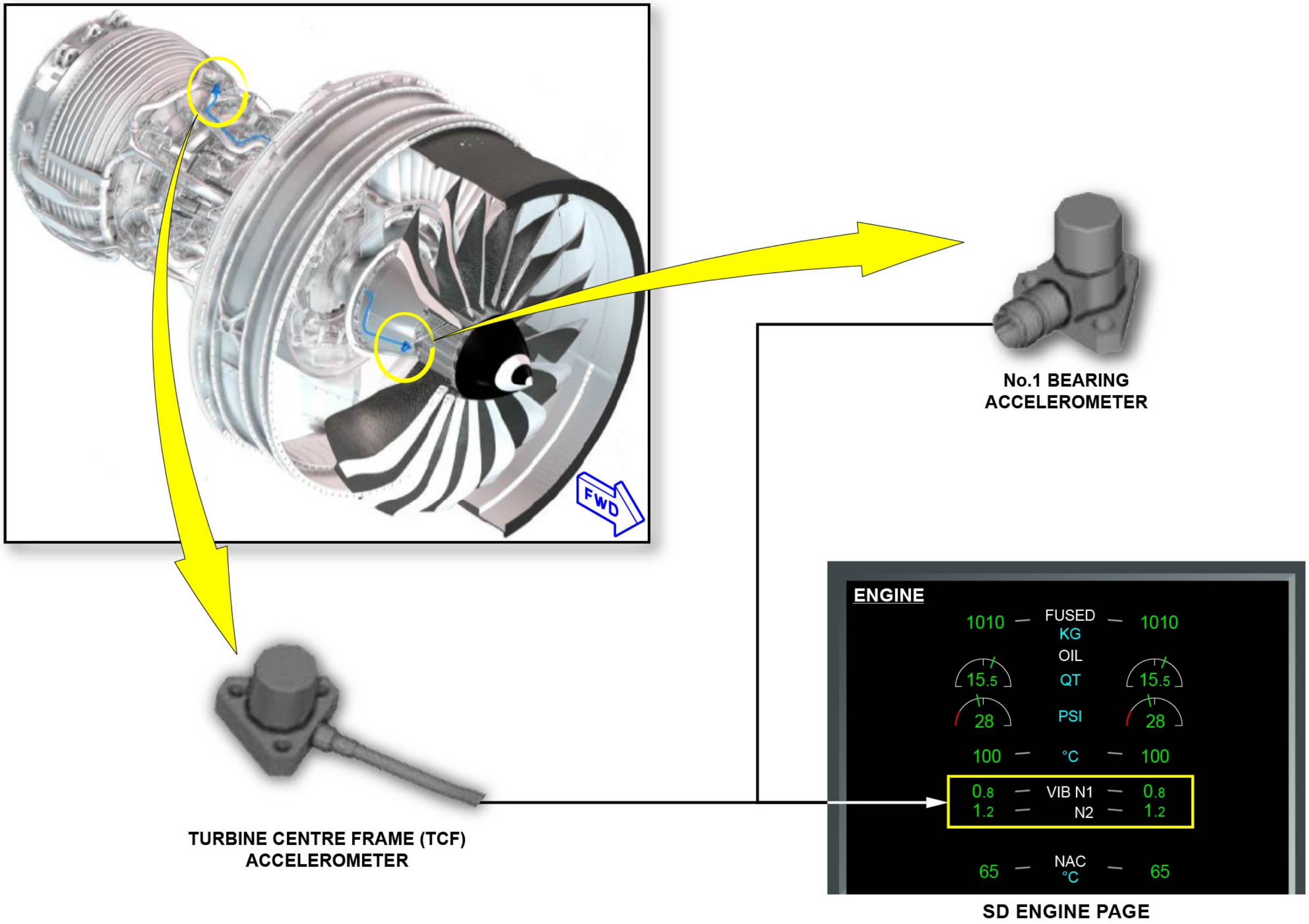
ENGINE MONITORING D/O

SECONDARY PARAMETERS (continued)

VIBRATION PARAMETERS DESCRIPTION

It is installed internally on the N°1 Bearing support at 8 o'clock position and its lead cable goes through the Fan Hub Strut 2 for the external connection.
The NOB accelerometer is not a LRU.
The TCF Accelerometer is installed on the Turbine Centre Frame at 11 o'clock position.
The TCF accelerometer is a LRU.


FWD
No.1 BEARING ACCELEROMETER
TURBINE CENTRE FRAME (TCF) ACCELEROMETER
ENGINE
1010
FUSED KG
1010
OIL
15.5
QT
15.5
28
PSI
28
100
°C
100
0.8
VIB N1
0.8
1.2
N2
1.2
65
NAC °C
65
SD ENGINE PAGE

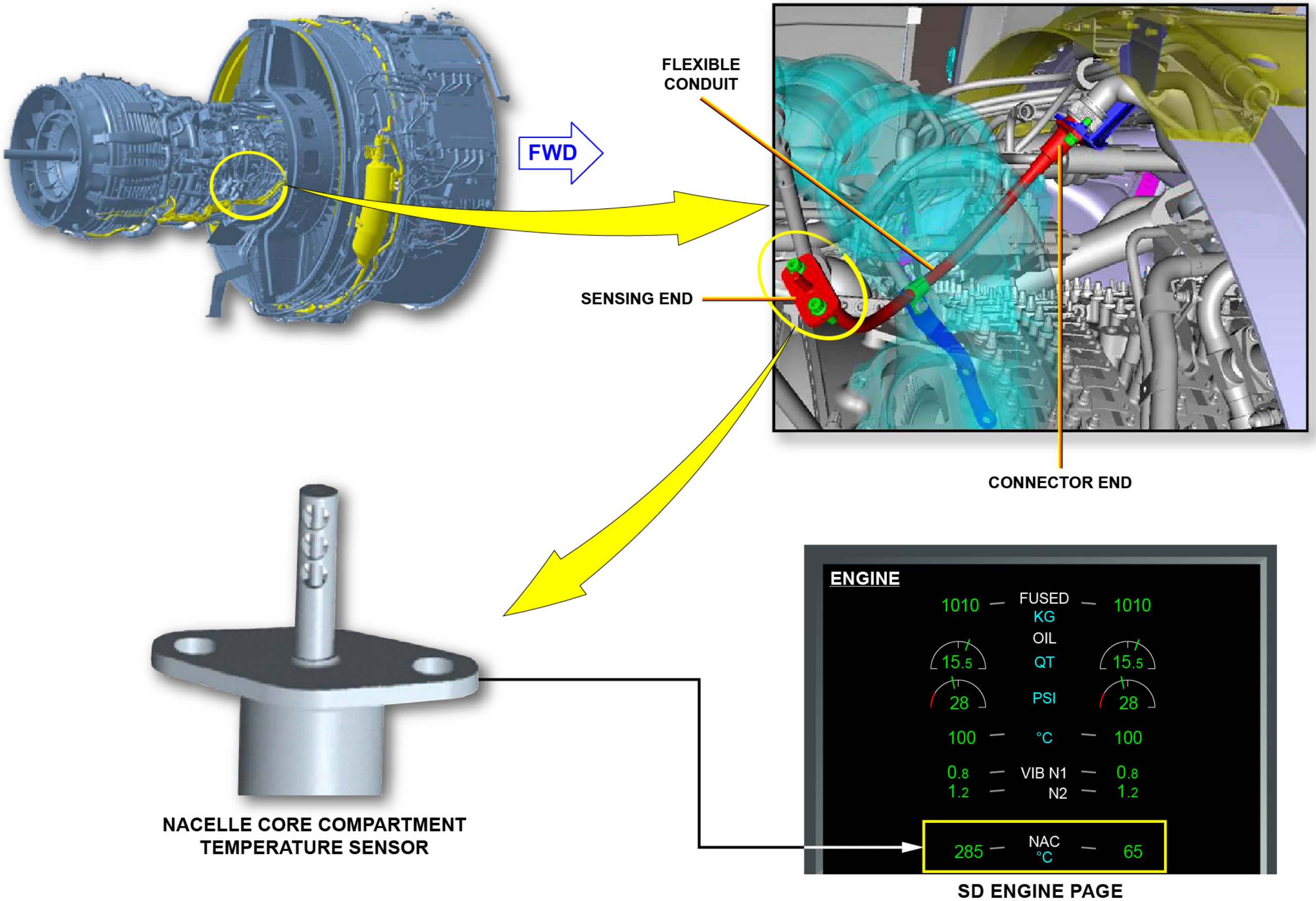
SECONDARY PARAMETERS - VIBRATION PARAMETERS DESCRIPTION

ENGINE MONITORING D/O

SECONDARY PARAMETERS (continued)

NACELLLE TEMPERATURE INDICATION

The EEC A receives the sensor signal and shares it with EEC B for display on ECAM SD ENGINE page. The sensor has no engine control function.
The core temperature sensor is an LRU.

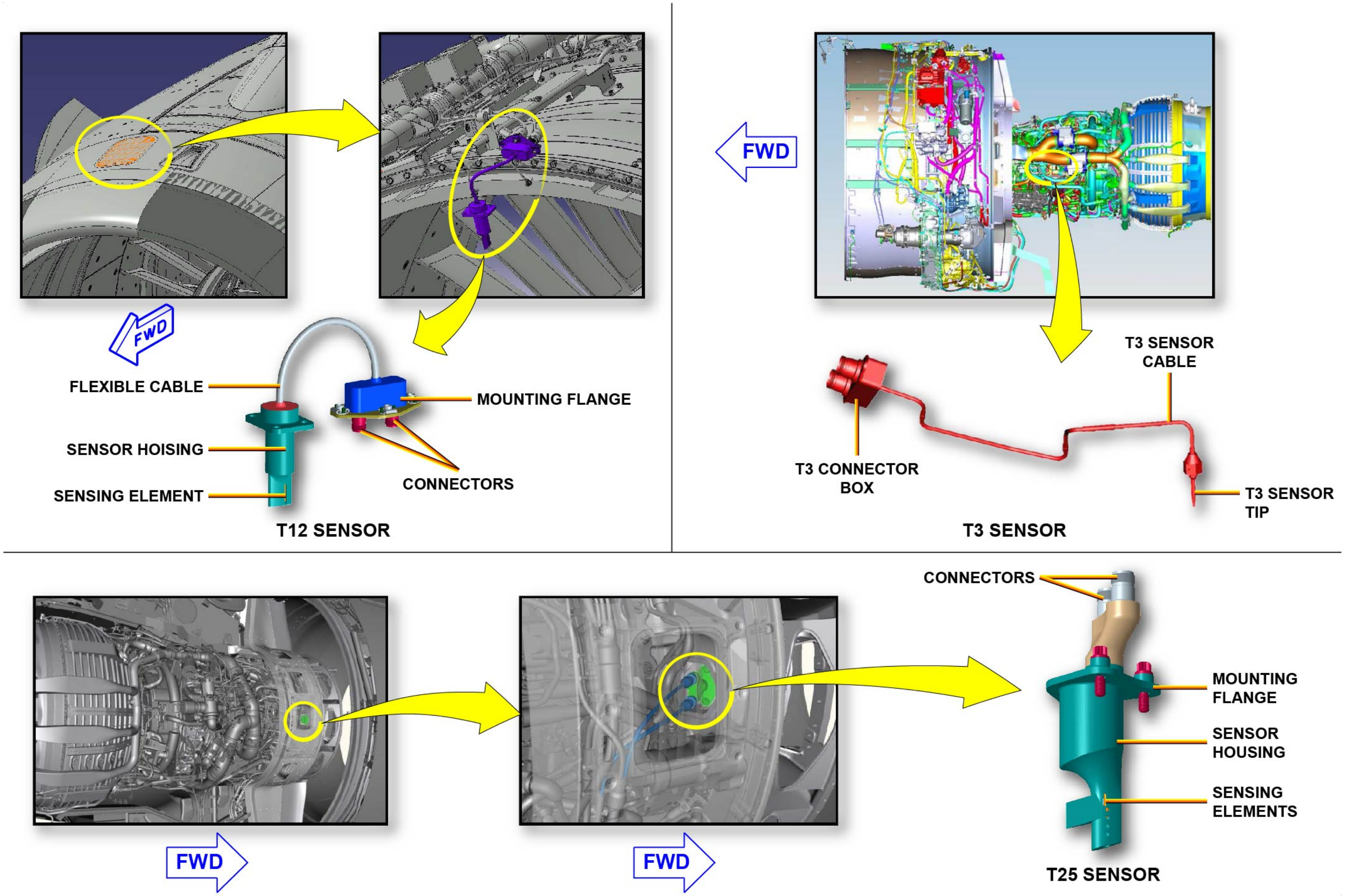

FWD
FLEXIBLE CONDUIT
SENSING END
CONNECTOR END
NACELLE CORE COMPARTMENT TEMPERATURE SENSOR
ENGINE
1010
FUSED KG
1010
OIL
15.5
QT
15.5
28
PSI
28
100
°C
100
0.8
VIB N1
0.8
1.2
N2
1.2
285
NAC °C
65
SD ENGINE PAGE

SECONDARY PARAMETERS - NACELLLE TEMPERATURE INDICATION

ENGINE MONITORING D/O

OTHER SENSORS FOR ENGINE CONTROL AND MONITORING

Various sensors are used by the EECs for the engine internal control and monitoring.
The T12 sensor transmits the fan inlet air temperature to the EECs for engine control for the Total Air Temperature (TAT) consolidation. The T12 sensor is installed in the engine air intake upstream the fan blades, at the 12 o'clock position.
It is a dual Resistive Thermal Device (RTD) and it is a LRU.
The T25 sensor measures the total temperature of the primary flow between the booster and High Pressure Compressor (HPC) and transmits the signal to the EECs for engine control. The T25 sensor is mounted on the Fan Hub, at the 3 o'clock position.
The T25 sensor is a Resistive Thermal Device (RTD) and it is a LRU.
The T3 sensor transmits the temperature of the HPC discharge airflow to the EECs for engine control.
The T3 sensor protrudes into the compressor discharge airflow between the Combustor Diffuser Nozzle (CDN) case and the combustor outer liner. It is installed at the 8 o'clock position.
It is of thermocouple type and it is an LRU.


FWD
FLEXIBLE CABLE
SENSOR HOISING
SENSING ELEMENT
MOUNTING FLANGE
CONNECTORS
T12 SENSOR
FWD
T3 SENSOR CABLE
T3 CONNECTOR BOX
T3 SENSOR TIP
T3 SENSOR
CONNECTORS
MOUNTING FLANGE
SENSOR HOUSING
SENSING ELEMENTS
FWD
FWD
T25 SENSOR

OTHER SENSORS FOR ENGINE CONTROL AND MONITORING

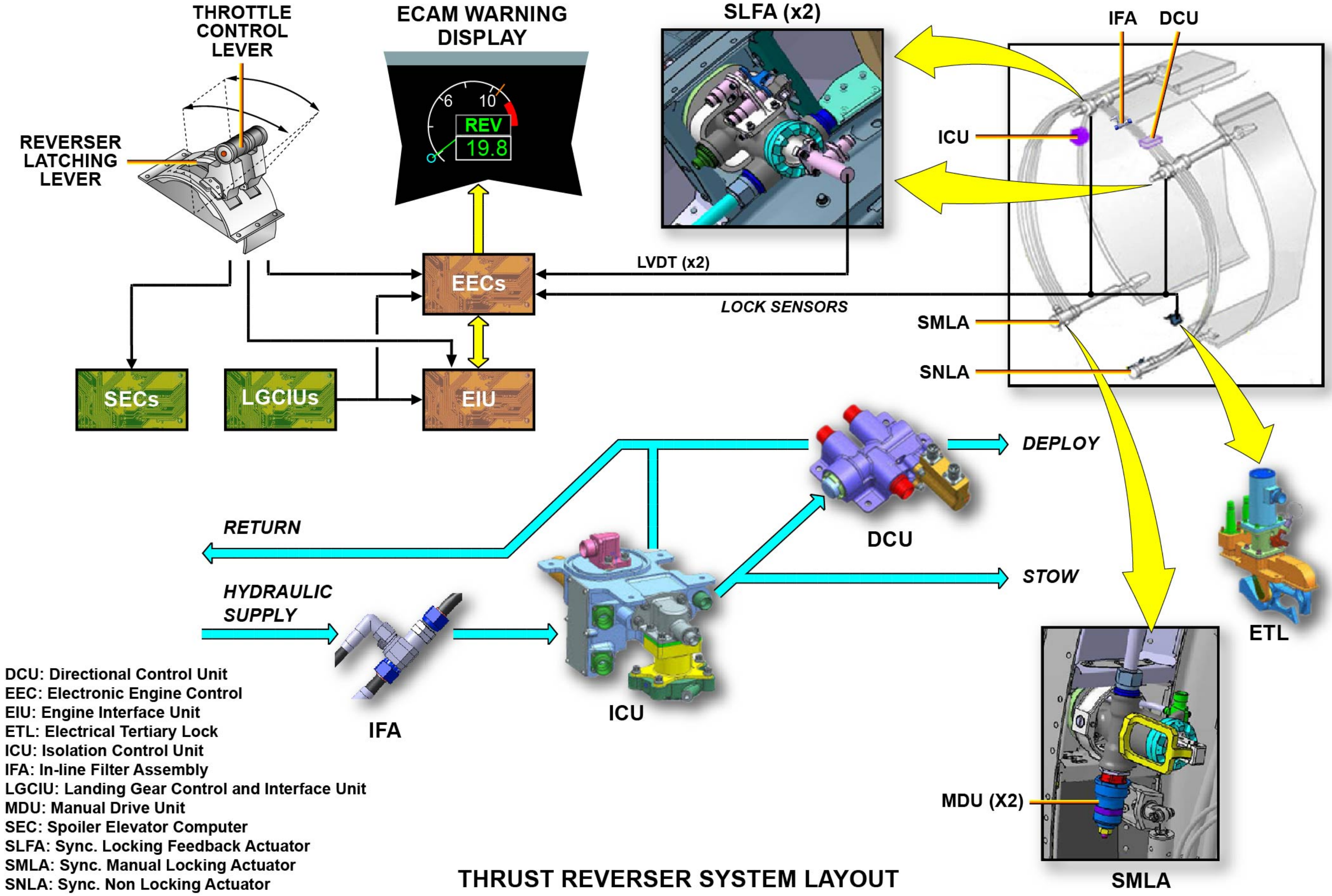
THRUST REVERSER SYSTEM D/O

THRUST REVERSER SYSTEM LAYOUT

The thrust reverser system is of the aerodynamic blockage type.
For each engine, it consists of two translating sleeves linked mechanically, ten blocker doors and twenty cascade vanes to redirect fan discharge airflow.
Each Thrust Reverser Actuation System (TRAS) is pressurized by its dedicated hydraulic power source:
- the green hydraulic pressure for engine 1,
- the yellow one for engine 2.

Each system is made of:
- one Isolation Control Unit (ICU) and a Directional Control Unit (DCU),
- two worm drive actuators per side (on the RH side, one Synchronization Locking Feedback Actuator (SLFA) and one Synchronization Manual Locking Actuator (SMLA); on the LH side, one SLFA and one Synchronization Non Locking Actuator (SNLA)),
- three synchronization flex shafts,
- locking and monitoring devices.

To avoid inadvertent deployment in flight, the system operates under multiple and independent commands of various components. It comprises three lines of defense: the Engine Interface Unit (EIU) control on the ICU and DCU, the Electronic Engine Control (EEC) control on the ICU and DCU, and Spoiler Elevator Computer (SEC) control on the Electrical Tertiary Lock (ETL).
Each computer receives the throttle position independently from a dedicated sensor and the EECs and EIU are able to cross check the various inputs.
The system also comprises three retention means: one primary lock in each upper actuator (SLFA) and one ETL at the bottom of the left translating sleeve.
The translating sleeves position is monitored by the SLFA Linear Variable Differential Transducers (LVDTs) and the retention means (locks) are monitored by their related dual proximity sensor.


THROTTLE CONTROL LEVER
REVERSER LATCHING LEVER
ECAM WARNING DISPLAY
6
10
REV
19.8
SLFA (x2)
IFA
DCU
ICU
LVDT (x2)
LOCK SENSORS
SMLA
SNLA
EECs
EIU
SECs
LGCIUs
DEPLOY
RETURN
STOW
HYDRAULIC SUPPLY
DCU
ICU
IFA
ETL
MDU (X2)
SMLA
THRUST REVERSER SYSTEM LAYOUT

DCU: Directional Control Unit
EEC: Electronic Engine Control
EIU: Engine Interface Unit
ETL: Electrical Tertiary Lock
ICU: Isolation Control Unit
IFA: In-line Filter Assembly
LGCIU: Landing Gear Control and Interface Unit
MDU: Manual Drive Unit
SEC: Spoiler Elevator Computer
SLFA: Sync. Locking Feedback Actuator
SMLA: Sync. Manual Locking Actuator
SNLA: Sync. Non Locking Actuator

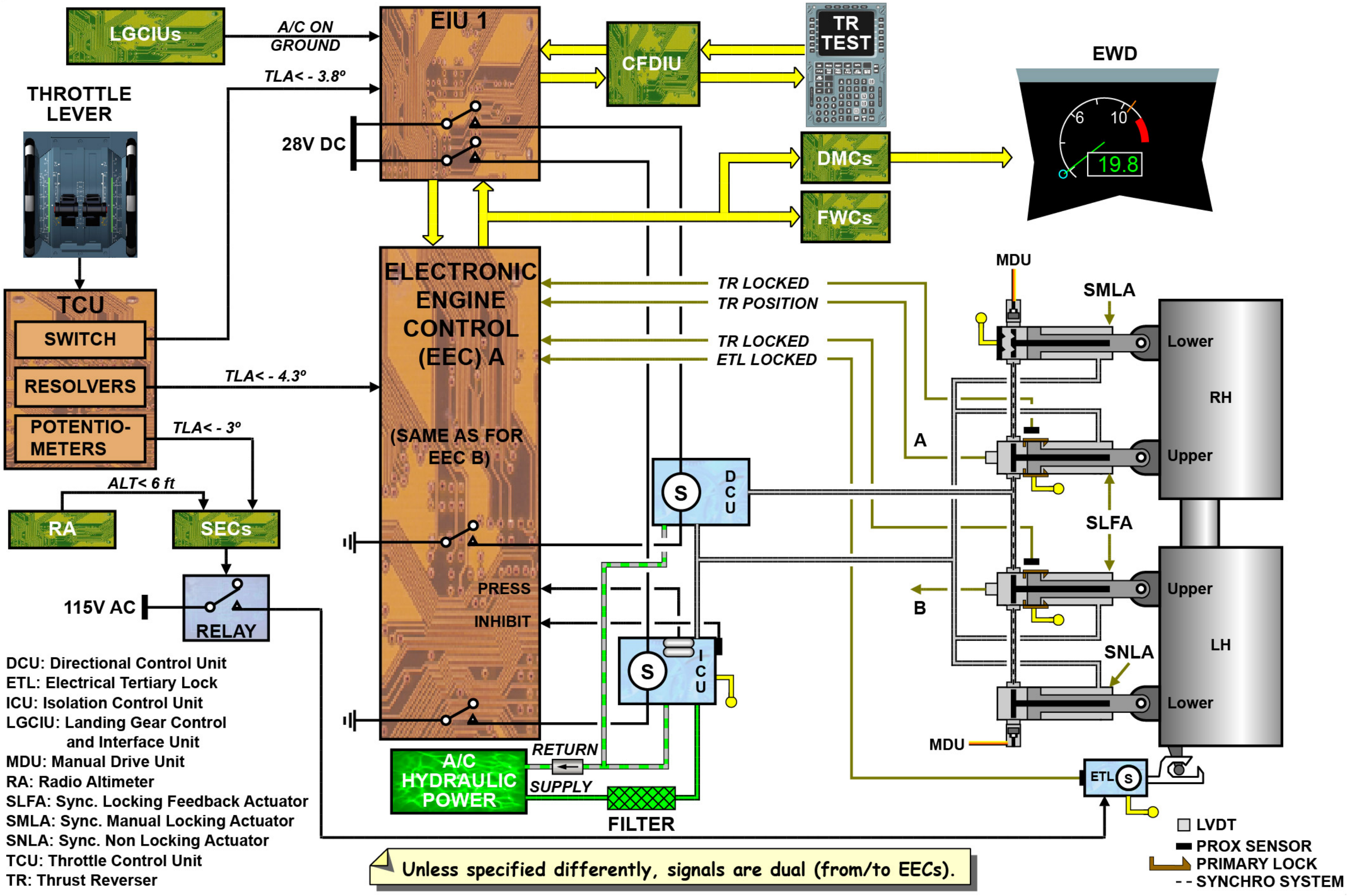
THRUST REVERSER SYSTEM LAYOUT

THRUST REVERSER SYSTEM D/O

DEPLOY SEQUENCE

The active Electronic Engine Control (EEC) confirms the engine is running. The thrust reversers are stowed, locked and not inhibited.
In these conditions:
- the ICU, DCU, Electrical Tertiary Lock (ETL) are de-energized to prevent pressurization,
- the 3 dual proximity sensors indicate locked,
- the ICU pressure switch indicates a low pressure,
- both LVDTs indicate a stowed condition,
- the ICU inhibition lever proximity sensor indicates a non-inhibited condition.

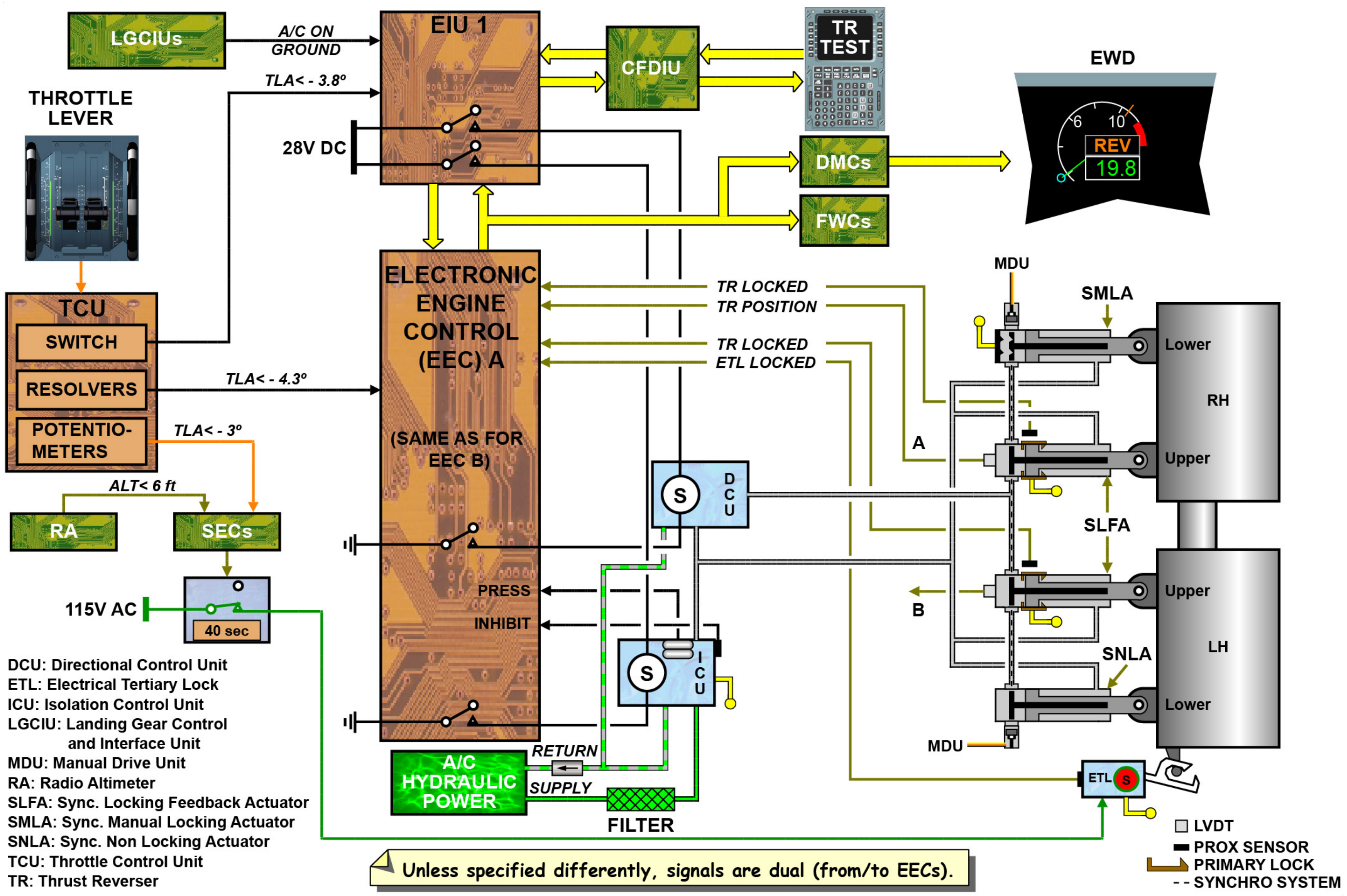
When the thrust-reverser lever is set to the deploy position, the following sequence occurs.
As soon as the Spoiler Elevator Computers (SECs) receive the signal from the Throttle Control Unit (TCU) potentiometers (Throttle Lever Angle (TLA) < -3°), and from the Radio Altimeter (RA) (altitude < 6 ft), they control the powering of the ETL to open for 40 seconds.
When the Engine Interface Unit (EIU) receives the signals from the TCU switch (TLA < -3.8°) and from the Landing Gear Control and Interface Units (LGCIUs) (aircraft on ground), it controls the closure of internal relays involved in the ICU and DCU powering.
When the EEC receives the signals from the TCU resolvers (TLA < -4.3°), it closes an internal relay to power the ICU to open. The pressure is sent to the actuators rod chambers to perform an overstow in order to release internal friction on primary locks prior unlocking.
When the EEC receives the pressurization signal from the ICU pressure switch and the unlocked signal from the ETL proximity sensor, it closes an internal relay to power the DCU to open. The pressure is sent to the actuators jack heads to release the actuators internal primary locks and command the translating sleeves deployment.
One second after the SLFA LVDTs indicate 85 % of travel, the EEC commands the engine to accelerate from reverse idle to max reverse thrust. Maximum allowable thrust is defined as a function of sleeve travel and TLA.
At 97% of travel, the EEC de-powers the ICU by opening its internal relay. The TRAS is de-pressurized.


LGCIUs
A/C ON
GROUND
EIU 1
CFDIU
TR
TEST
EWD
6
10
19.8
THROTTLE
LEVER
TLA< - 3.8º
28V DC
DMCs
FWCs
TCU
SWITCH
RESOLVERS
POTENTIO-
METERS
TLA< - 4.3º
TLA< - 3º
ELECTRONIC
ENGINE
CONTROL
(EEC) A
(SAME AS FOR
EEC B)
TR LOCKED
TR POSITION
TR LOCKED
ETL LOCKED
MDU
SMLA
Lower
RH
Upper
A
S
D
C
U
SLFA
ALT< 6 ft
RA
SECs
Upper
B
LH
SNLA
Lower
115V AC
RELAY
PRESS
INHIBIT
S
I
C
U
MDU
A/C
HYDRAULIC
POWER
RETURN
SUPPLY
FILTER
ETL
S
LVDT
PROX SENSOR
PRIMARY LOCK
- - SYNCHRO SYSTEM

DCU: Directional Control Unit
ETL: Electrical Tertiary Lock
ICU: Isolation Control Unit
LGCIU: Landing Gear Control
and Interface Unit
MDU: Manual Drive Unit
RA: Radio Altimeter
SLFA: Sync. Locking Feedback Actuator
SMLA: Sync. Manual Locking Actuator
SNLA: Sync. Non Locking Actuator
TCU: Throttle Control Unit
TR: Thrust Reverser

Unless specified differently, signals are dual (from/to EECs).

DEPLOY SEQUENCE


LGCIUs
A/C ON GROUND
TLA< - 3.8°
EIU 1
28V DC
CFDIU
TR TEST
EWD
6
10
REV
19.8
DMCs
FWCs
THROTTLE LEVER
TCU
SWITCH
RESOLVERS
POTENTIO-METERS
TLA< - 4.3°
TLA< - 3°
ALT< 6 ft
RA
SECs
115V AC
40 sec
ELECTRONIC ENGINE CONTROL (EEC) A
(SAME AS FOR EEC B)
PRESS
INHIBIT
A/C HYDRAULIC POWER
RETURN
SUPPLY
FILTER
TR LOCKED
TR POSITION
TR LOCKED
ETL LOCKED
MDU
SMLA
Lower
RH
Upper
A
S
DCU
SLFA
B
Upper
LH
SNLA
Lower
S
ICU
MDU
ETL
S

DCU: Directional Control Unit
ETL: Electrical Tertiary Lock
ICU: Isolation Control Unit
LGCIU: Landing Gear Control and Interface Unit
MDU: Manual Drive Unit
RA: Radio Altimeter
SLFA: Sync. Locking Feedback Actuator
SMLA: Sync. Manual Locking Actuator
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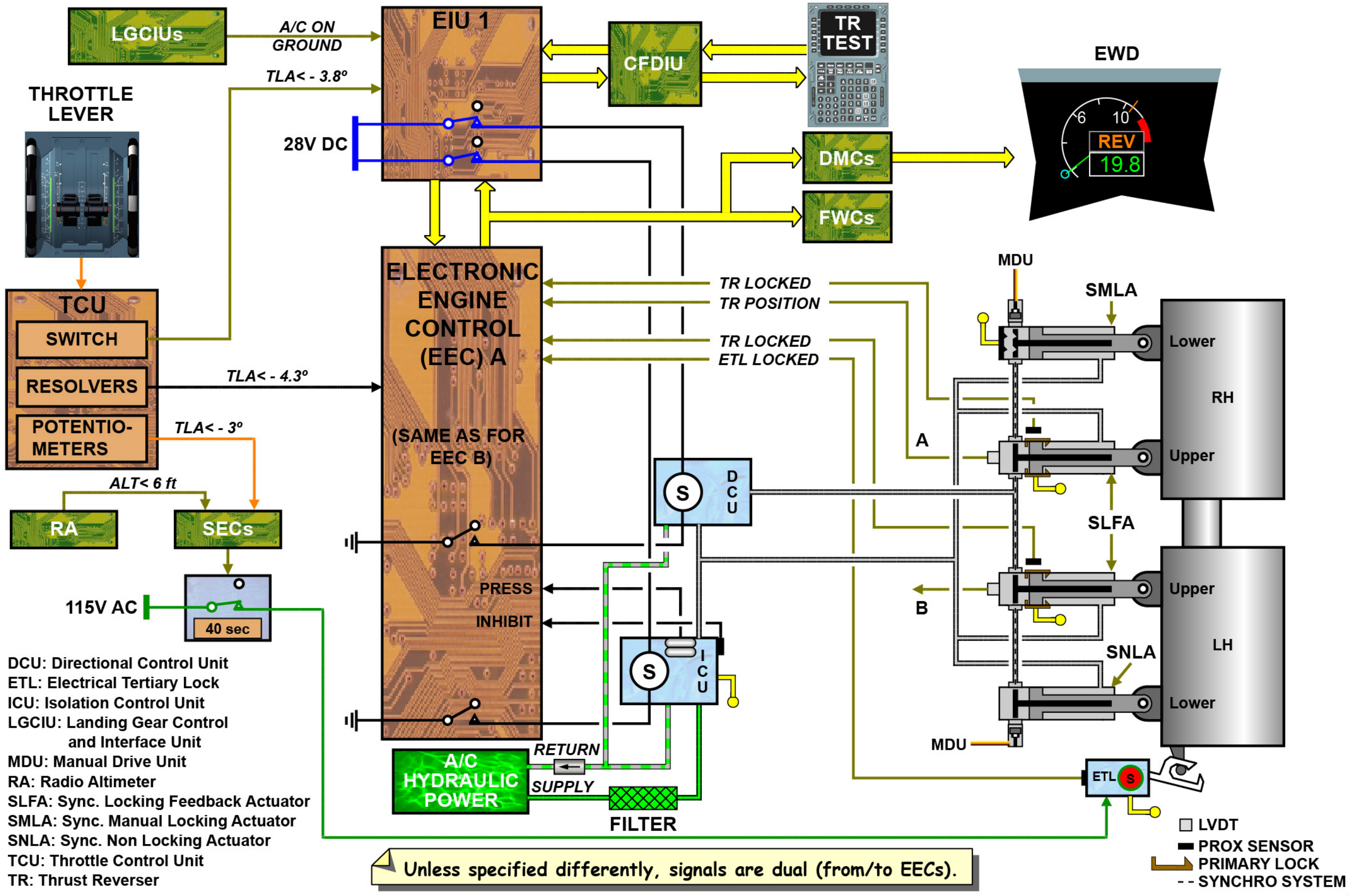
Unless specified differently, signals are dual (from/to EECs).

□ LVDT
▬ PROX SENSOR
PRIMARY LOCK
- - SYNCHRO SYSTEM

DEPLOY SEQUENCE


LGCIUs
A/C ON
GROUND
TLA< - 3.8º
EIU 1
CFDIU
TR
TEST
EWD
6
10
REV
19.8
THROTTLE
LEVER
28V DC
DMCs
FWCs
TCU
SWITCH
RESOLVERS
POTENTIO-
METERS
TLA< - 4.3º
TLA< - 3º
ELECTRONIC
ENGINE
CONTROL
(EEC) A
(SAME AS FOR
EEC B)
TR LOCKED
TR POSITION
TR LOCKED
ETL LOCKED
MDU
SMLA
Lower
RH
Upper
A
SLFA
Upper
LH
B
SNLA
Lower
MDU
S
DCU
S
ICU
ALT< 6 ft
RA
SECs
115V AC
40 sec
PRESS
INHIBIT
RETURN
SUPPLY
A/C
HYDRAULIC
POWER
FILTER
ETL
S
LVDT
PROX SENSOR
PRIMARY LOCK
- - SYNCHRO SYSTEM

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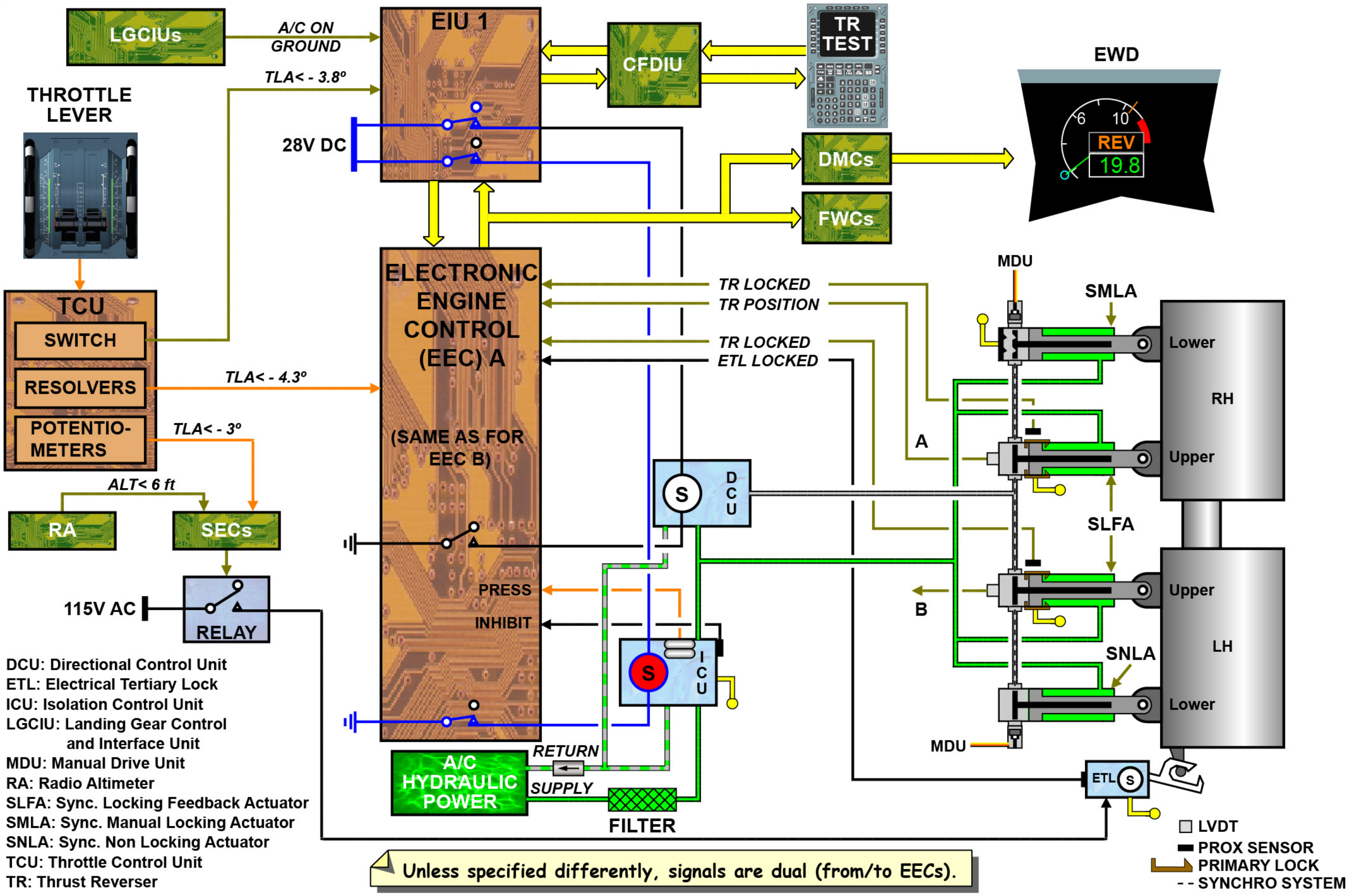
TR: Thrust Reverser

Unless specified differently, signals are dual (from/to EECs).

DEPLOY SEQUENCE


LGCIUs
A/C ON GROUND
TLA< - 3.8º
EIU 1
CFDIU
TR TEST
EWD
6
10
REV
19.8
DMCs
FWCs
THROTTLE LEVER
28V DC
TCU
SWITCH
RESOLVERS
POTENTIO-METERS
TLA< - 4.3º
TLA< - 3º
ALT< 6 ft
RA
SECs
115V AC
RELAY
ELECTRONIC ENGINE CONTROL (EEC) A
(SAME AS FOR EEC B)
PRESS
INHIBIT
MDU
SMLA
TR LOCKED
TR POSITION
TR LOCKED
ETL LOCKED
Lower
RH
Upper
A
S
DCU
SLFA
B
Upper
SNLA
LH
Lower
S
ICU
MDU
RETURN
SUPPLY
A/C HYDRAULIC POWER
FILTER
ETL
S

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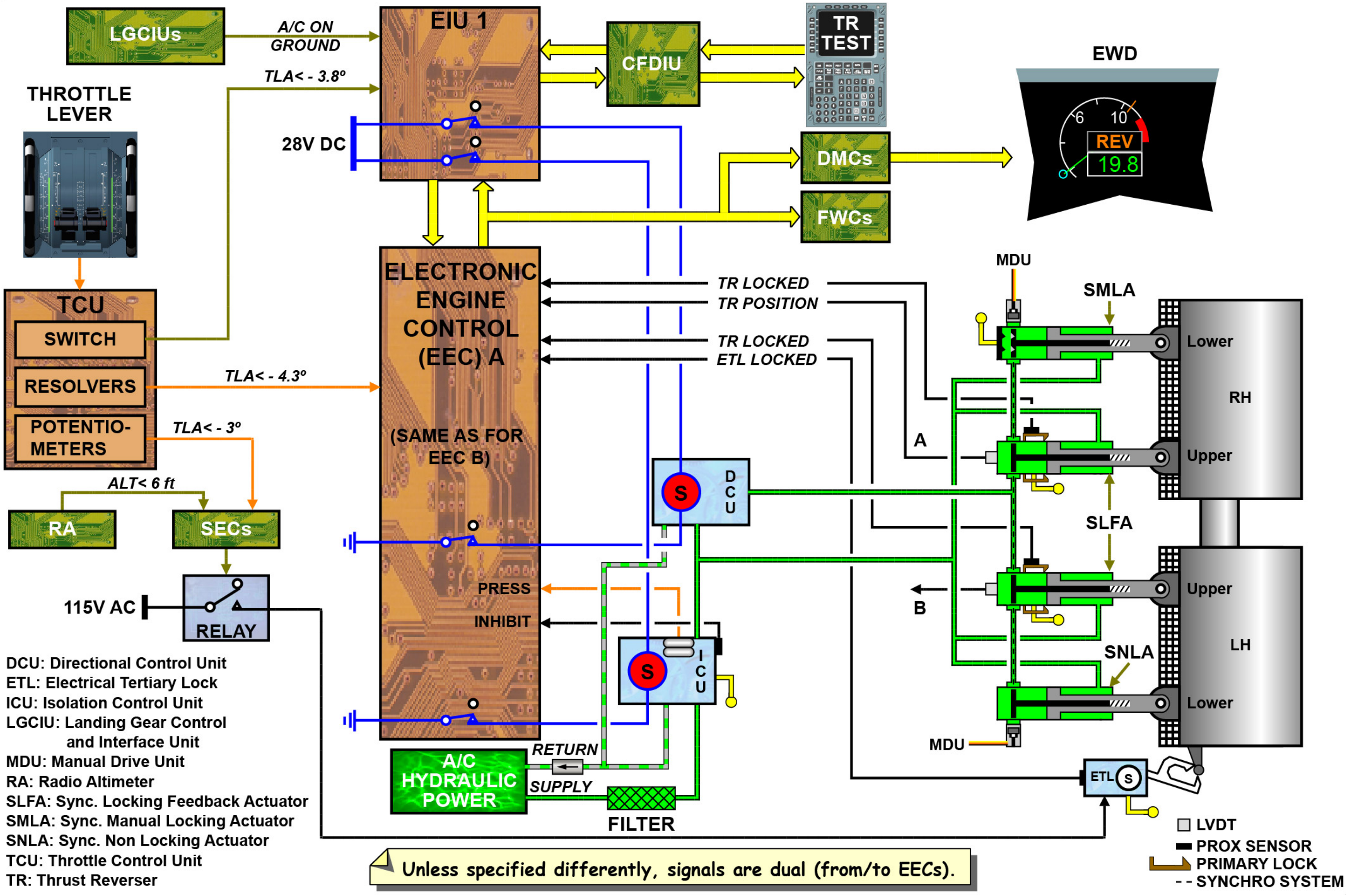
☐ LVDT
▬ PROX SENSOR
PRIMARY LOCK
- - SYNCHRO SYSTEM

DEPLOY SEQUENCE


LGCIUs
A/C ON
GROUND
EIU 1
CFDIU
TR
TEST
EWD
THROTTLE
LEVER
TLA< - 3.8º
28V DC
6
10
REV
19.8
DMCs
FWCs
ELECTRONIC
ENGINE
CONTROL
(EEC) A
(SAME AS FOR
EEC B)
TCU
SWITCH
RESOLVERS
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METERS
TLA< - 4.3º
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RA
SECs
115V AC
RELAY
MDU
SMLA
TR LOCKED
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TR LOCKED
ETL LOCKED
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RH
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A
S
D
C
U
SLFA
Upper
B
PRESS
INHIBIT
S
I
C
U
SNLA
LH
Lower
MDU
RETURN
SUPPLY
A/C
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POWER
FILTER
ETL
S
☐ LVDT
▬ PROX SENSOR
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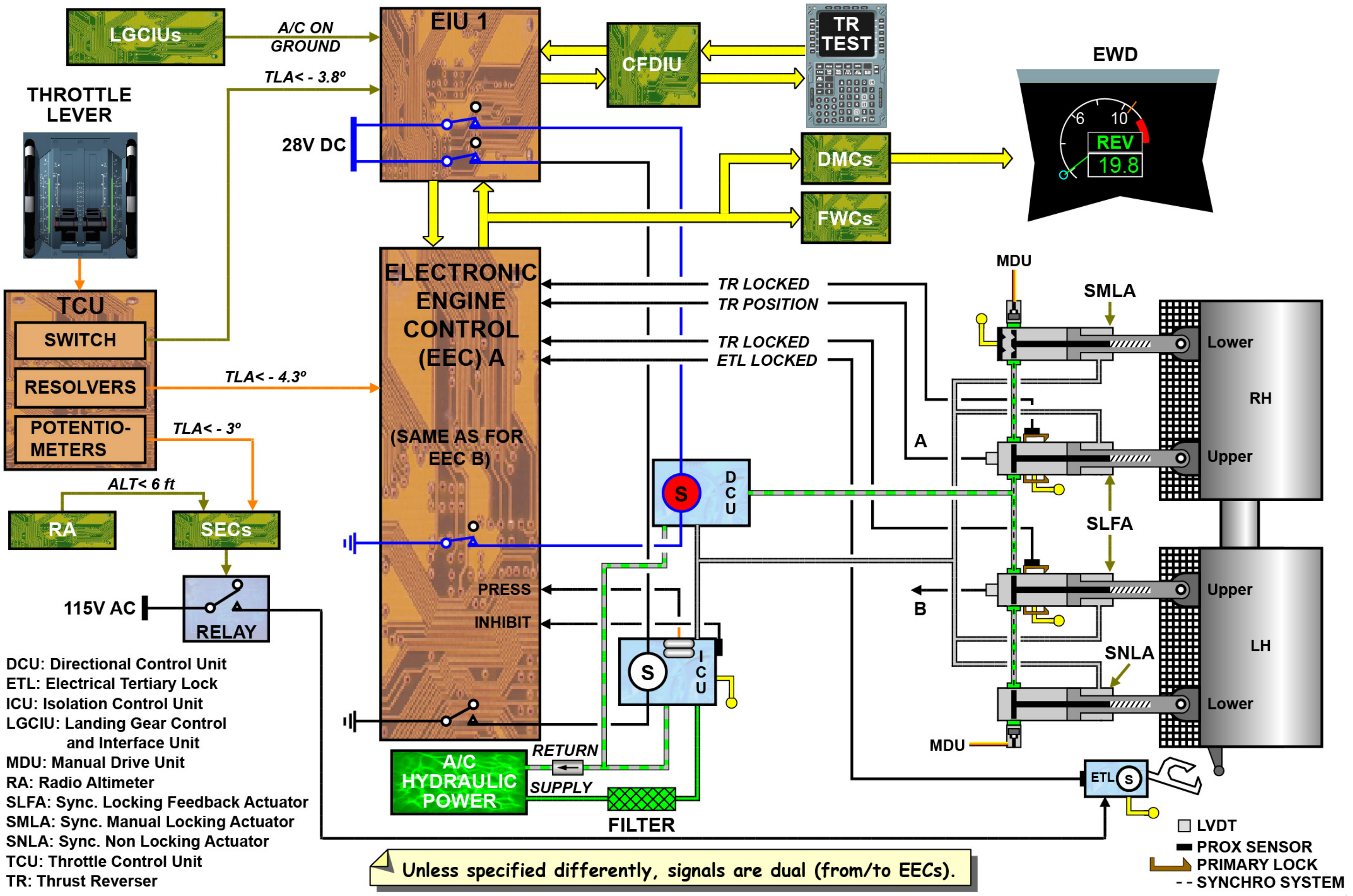
LGCIUs
A/C ON GROUND
TLA< - 3.8°
EIU 1
CFDIU
TR TEST
EWD
6
10
REV
19.8
28V DC
DMCs
FWCs
THROTTLE LEVER
TCU
SWITCH
RESOLVERS
POTENTIO-METERS
TLA< - 4.3°
TLA< - 3°
ALT< 6 ft
RA
SECs
115V AC
RELAY
ELECTRONIC ENGINE CONTROL (EEC) A
(SAME AS FOR EEC B)
TR LOCKED
TR POSITION
TR LOCKED
ETL LOCKED
MDU
SMLA
Lower
RH
Upper
A
D C U
S
SLFA
PRESS
INHIBIT
B
Upper
LH
SNLA
Lower
S
I C U
MDU
RETURN
SUPPLY
A/C HYDRAULIC POWER
FILTER
ETL
S
LVDT
PROX SENSOR
PRIMARY LOCK
- - SYNCHRO SYSTEM

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DEPLOY SEQUENCE

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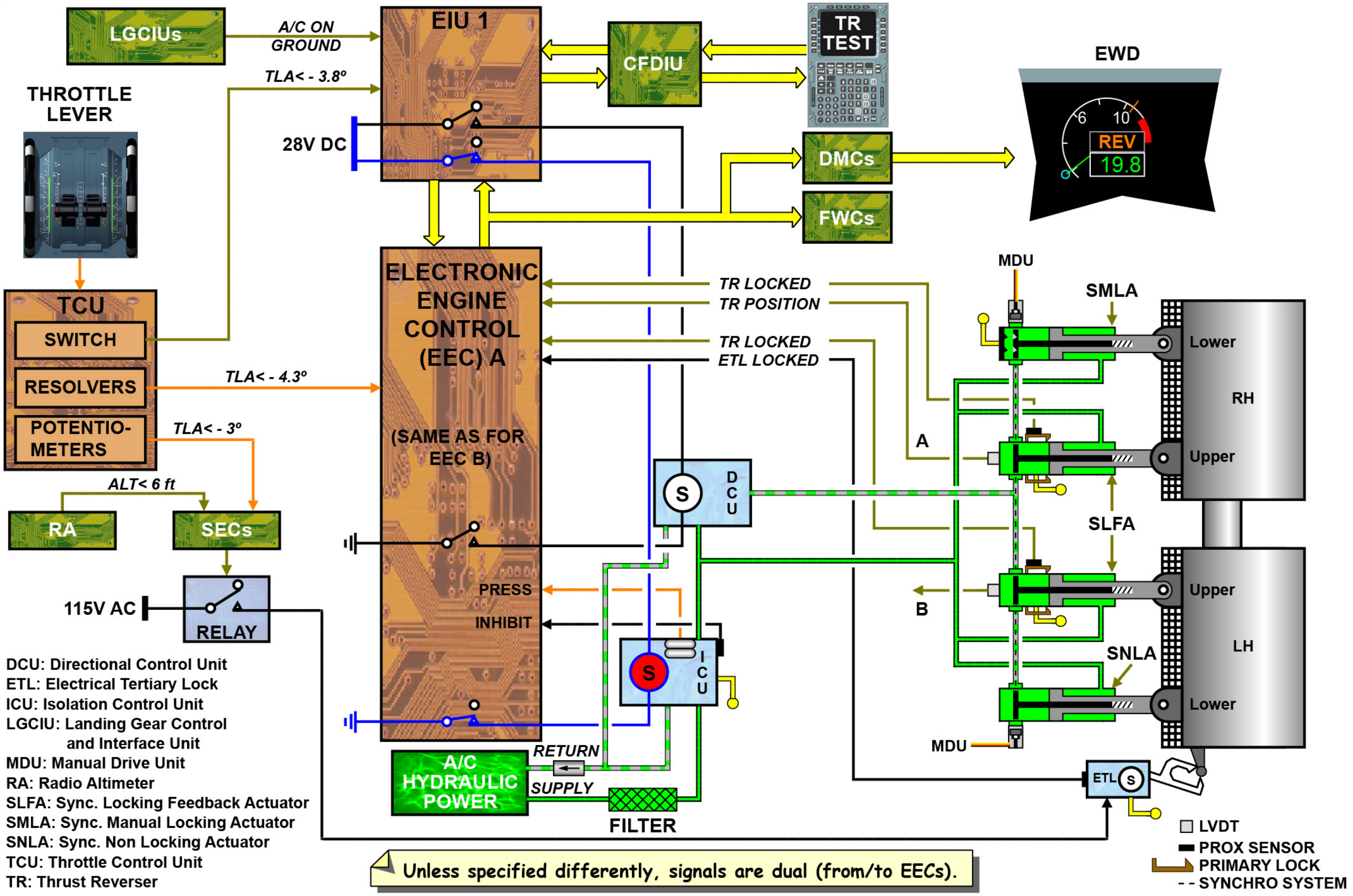
THRUST REVERSER SYSTEM D/O

STOW SEQUENCE

When the thrust-reverser lever is set to the stow position, the following sequence occurs.
When the EEC and the EIU receive the signals from the TCU to confirm the idle selection, they first de-energize the DCU and then the EEC closes its internal contact to re-open the ICU. The pressure is sent to the actuators rod chambers to stow the translating sleeves.
The EEC will limit the engine thrust to selected forward idle mode until the Thrust Reverser is confirmed locked.
When reaching the end of retraction, the ETL is re-engaged first mechanically by the roller on the left translating sleeve, then the two primary locks are re-engaged when reaching the overstow position.
2 seconds after the overstow position is detected by the LVDTs, the EEC de-energizes the ICU to release the pressure in the actuators. Then the EIU opens its internal relay to isolate the ICU powering. The TRAS is de-pressurized.


LGCIUs
A/C ON
GROUND
EIU 1
CFDIU
TR
TEST
EWD
THROTTLE
LEVER
TLA< - 3.8º
28V DC
DMCs
6
10
REV
19.8
FWCs
TCU
SWITCH
RESOLVERS
POTENTIO-
METERS
ELECTRONIC
ENGINE
CONTROL
(EEC) A
(SAME AS FOR
EEC B)
TLA< - 4.3º
TLA< - 3º
ALT< 6 ft
RA
SECs
115V AC
RELAY
MDU
SMLA
TR LOCKED
TR POSITION
TR LOCKED
ETL LOCKED
Lower
RH
Upper
A
S
DCU
SLFA
PRESS
INHIBIT
Upper
B
LH
SNLA
S
ICU
Lower
MDU
RETURN
SUPPLY
A/C
HYDRAULIC
POWER
FILTER
ETL
S
☐ LVDT
▬ PROX SENSOR
PRIMARY LOCK
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SNLA: Sync. Non Locking Actuator
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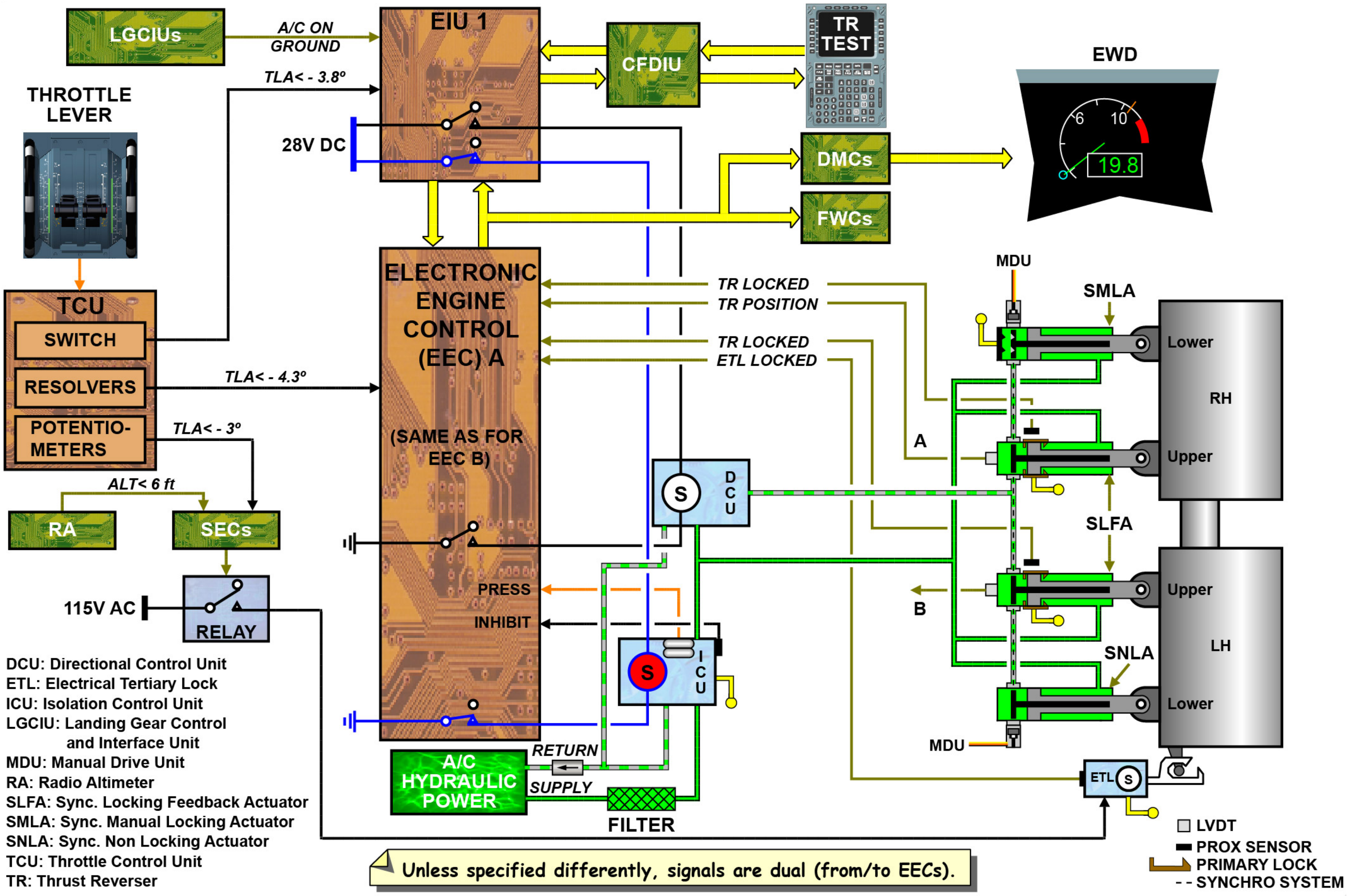
TR: Thrust Reverser

Unless specified differently, signals are dual (from/to EECs).

STOW SEQUENCE


LGCIUs
A/C ON GROUND
EIU 1
CFDIU
TR TEST
EWD
6
10
19.8
TLA< - 3.8°
THROTTLE LEVER
28V DC
DMCs
FWCs
ELECTRONIC ENGINE CONTROL (EEC) A
(SAME AS FOR EEC B)
TCU
SWITCH
RESOLVERS
POTENTIO-METERS
TLA< - 4.3°
TLA< - 3°
ALT< 6 ft
RA
SECs
115V AC
RELAY
TR LOCKED
TR POSITION
TR LOCKED
ETL LOCKED
MDU
SMLA
Lower
RH
Upper
A
S
DCU
SLFA
PRESS
INHIBIT
B
Upper
LH
SNLA
S
ICU
Lower
MDU
RETURN
SUPPLY
A/C HYDRAULIC POWER
FILTER
ETL
S
LVDT
PROX SENSOR
PRIMARY LOCK
- - SYNCHRO SYSTEM

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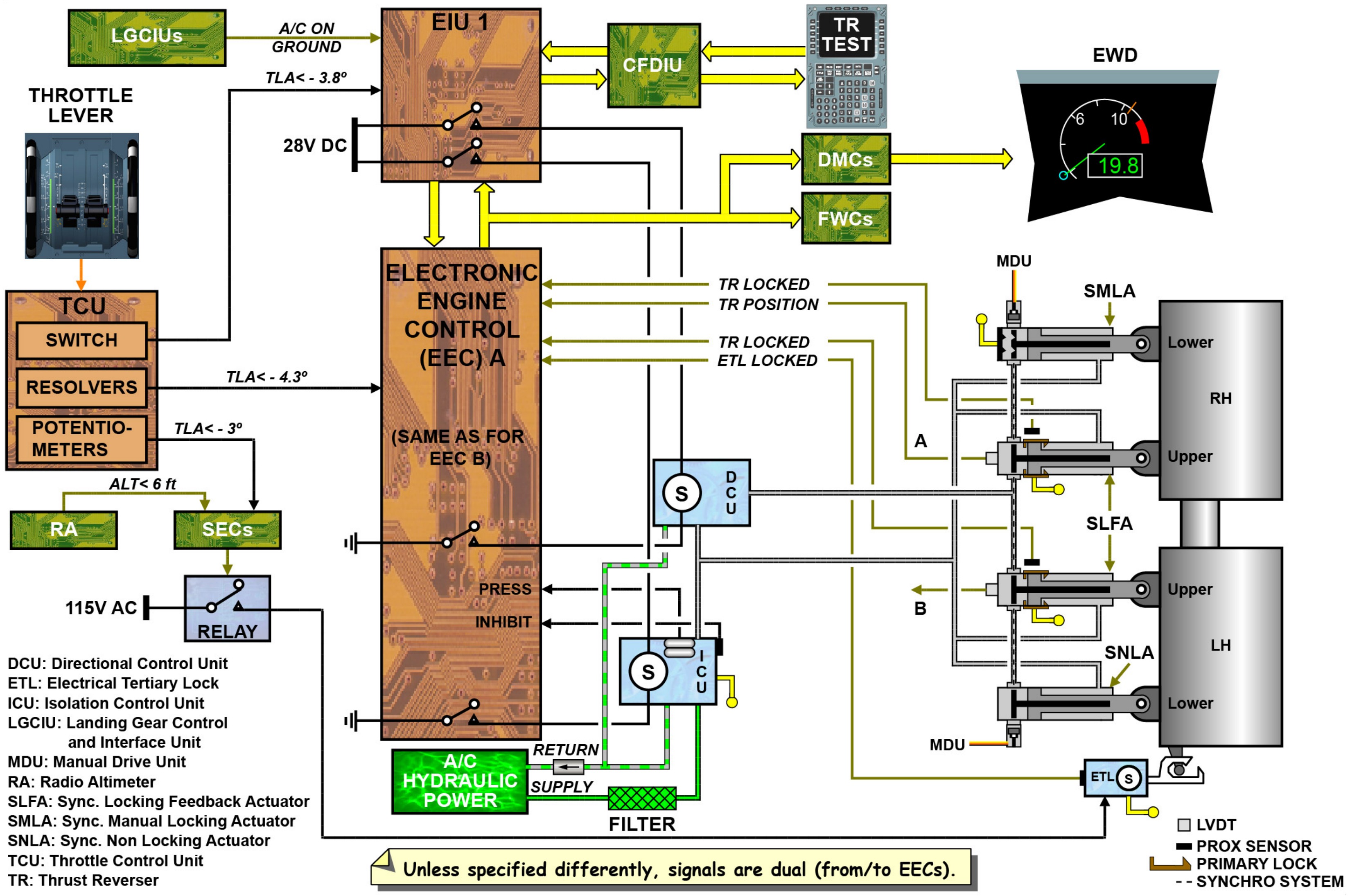
TR: Thrust Reverser

Unless specified differently, signals are dual (from/to EECs).

STOW SEQUENCE


LGCIUs
A/C ON GROUND
EIU 1
CFDIU
TR TEST
EWD
THROTTLE LEVER
TLA< - 3.8°
28V DC
6
10
19.8
DMCs
FWCs
TCU
SWITCH
RESOLVERS
POTENTIO-METERS
TLA< - 4.3°
TLA< - 3°
ELECTRONIC ENGINE CONTROL (EEC) A
(SAME AS FOR EEC B)
MDU
SMLA
TR LOCKED
TR POSITION
TR LOCKED
ETL LOCKED
Lower
RH
Upper
A
S
DCU
SLFA
ALT< 6 ft
RA
SECs
115V AC
RELAY
PRESS
INHIBIT
B
Upper
LH
SNLA
S
ICU
Lower
MDU
RETURN
A/C HYDRAULIC POWER
SUPPLY
FILTER
ETL
S
☐ LVDT
▬ PROX SENSOR
PRIMARY LOCK
- - SYNCHRO SYSTEM

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TCU: Throttle Control Unit
TR: Thrust Reverser

Unless specified differently, signals are dual (from/to EECs).

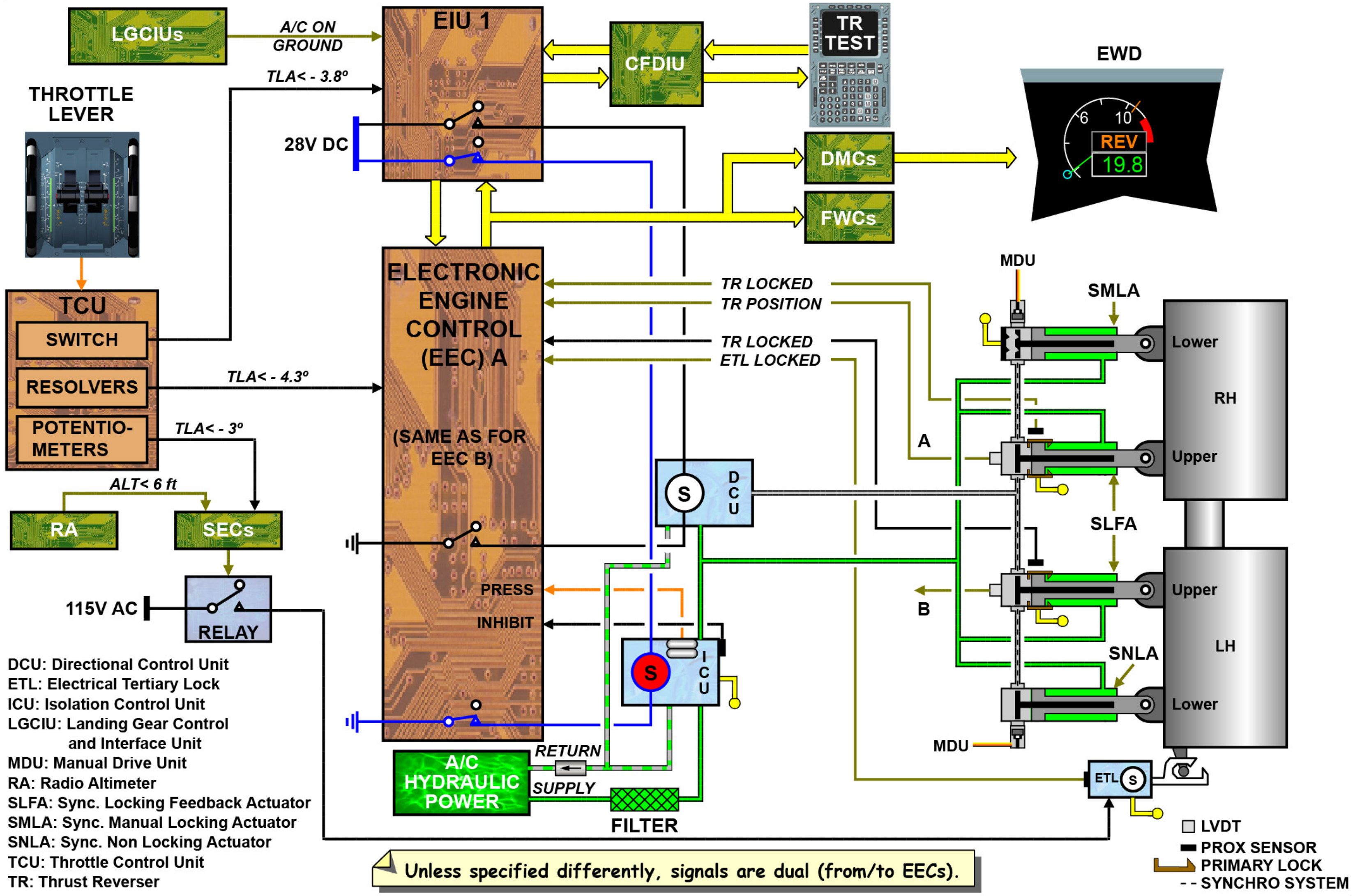
STOW SEQUENCE

THRUST REVERSER SYSTEM D/O

GROUND ASSISTED STOW SEQUENCE (GASS)

The EEC shall initiate a thrust reverser GASS operation only on ground in order to lock the thrust reverser system:
- if at least one primary lock is detected unlock after the normal stow sequence or,
- after the engine start.

The GASS shall be initiated by energizing the ICU (overstow command) when all the following conditions are fulfilled:
- the aircraft is on ground,
- the throttle is in forward thrust region and less than CL position,
- no stow sequence is being commanded,
- the engine is running,
- one or two primary locks are seen unlocked,
- the sleeve position is less than 11% of travel,
- the thrust reverser is not inhibited,
- the fire handle has not been pulled.


LGCIUs
A/C ON
GROUND
EIU 1
CFDIU
TR
TEST
EWD
6
10
REV
19.8
TLA< - 3.8º
THROTTLE
LEVER
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SWITCH
RESOLVERS
POTENTIO-
METERS
TLA< - 4.3º
TLA< - 3º
ALT< 6 ft
RA
SECs
115V AC
RELAY
ELECTRONIC
ENGINE
CONTROL
(EEC) A
(SAME AS FOR
EEC B)
TR LOCKED
TR POSITION
TR LOCKED
ETL LOCKED
MDU
SMLA
Lower
RH
Upper
A
S
D
C
U
SLFA
Upper
B
LH
SNLA
Lower
PRESS
INHIBIT
S
I
C
U
MDU
RETURN
A/C
HYDRAULIC
POWER
SUPPLY
FILTER
ETL
S
☐ LVDT
▬ PROX SENSOR
PRIMARY LOCK
- - SYNCHRO SYSTEM

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TR: Thrust Reverser

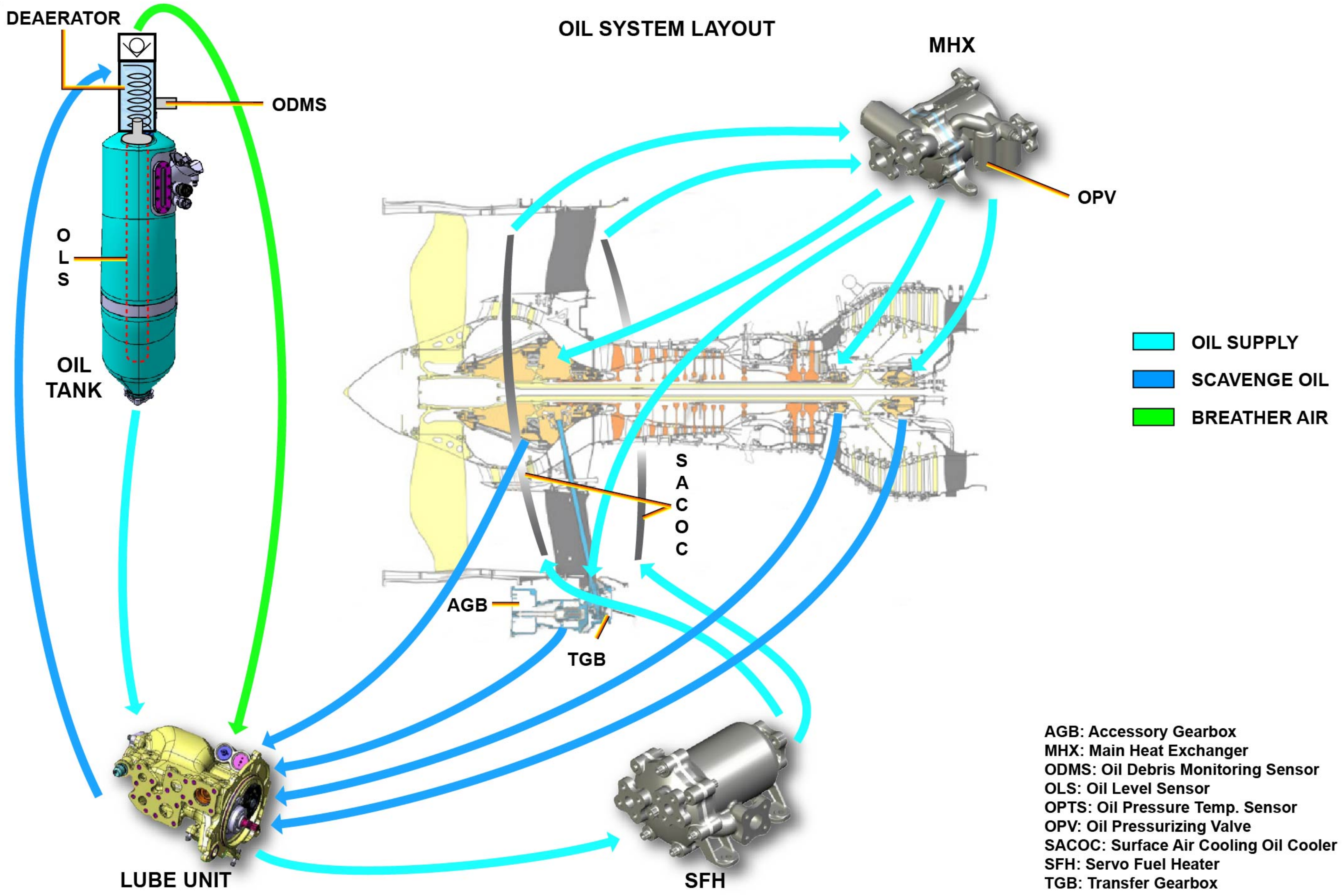
Unless specified differently, signals are dual (from/to EECs).

GROUND ASSISTED STOW SEQUENCE (GASS)

OIL SYSTEM D/O

OIL SYSTEM LAYOUT

The oil system:
- Lubricates the engine bearings, Transfer Gearbox (TGB), Main Gearbox (MGB) with filtered oil,
- Regulates the temperature of the:
- engine oil with the Main fuel/oil Heat Exchanger (MHX) and the Surface Air Cooling Air Cooler (SACOC),
- engine fuel with the Servo Fuel Heater (SFH),
- Scavenges the hot lubrication oil back to the tank,
- Vents overboard the excess of sealing air from the bearing compartments (sumps).


OIL SYSTEM LAYOUT
DEAERATOR
ODMS
O L S
OIL TANK
MHX
OPV
S A C O C
AGB
TGB
LUBE UNIT
SFH
OIL SUPPLY
SCAVENGE OIL
BREATHER AIR

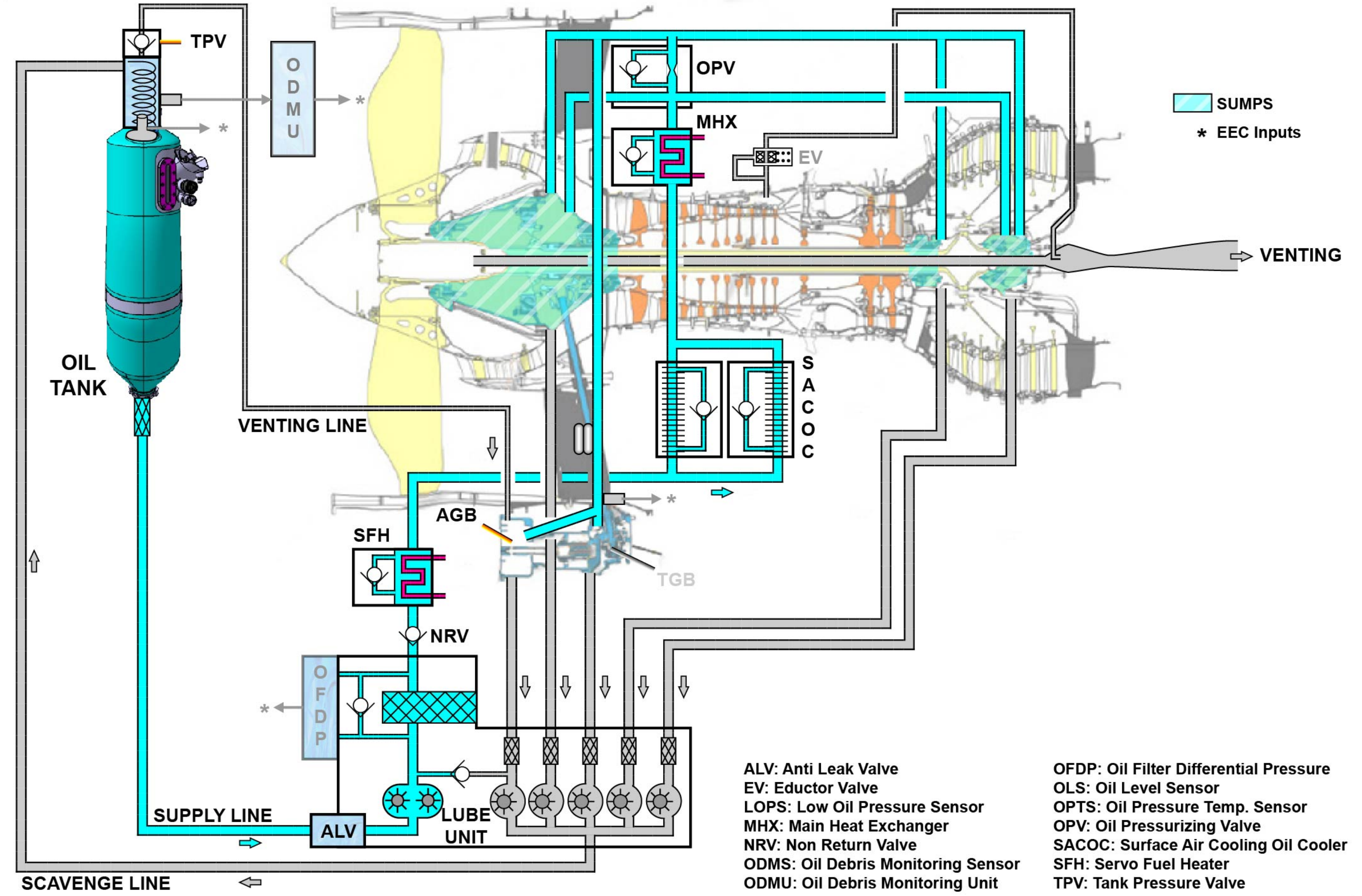
AGB: Accessory Gearbox
MHX: Main Heat Exchanger
ODMS: Oil Debris Monitoring Sensor
OLS: Oil Level Sensor
OPTS: Oil Pressure Temp. Sensor
OPV: Oil Pressurizing Valve
SACOC: Surface Air Cooling Oil Cooler
SFH: Servo Fuel Heater
TGB: Transfer Gearbox

OIL SYSTEM LAYOUT

OIL SYSTEM D/O

OIL SUPPLY

Oil flows from the pressurized oil tank to the dual lube pump in the Lubrication Unit.
The inlet on the Lubrication Unit is fitted with an Anti Leakage Valve (ALV) to avoid oil to flow by gravity from the tank to the Lube Unit and end up in the Accessory Gearbox (AGB).
The pressurized oil is directed to the supply oil filter and then to the heat exchangers via a Non Return Valve (NRV).
The NRV prevents oil from draining from heat exchangers (located above the supply pump) down to the AGB through the Lube Unit.
The oil is cooled down when passing through the SFH, the SACOCs and the MHX.
The Oil Pressurizing Valve (OPV) at the oil outlet of the MHX, enables pressurized oil to feed the engine oil dampers.


TPV
O D M U
*
OIL TANK
VENTING LINE
OPV
MHX
EV
SUMPS
* EEC Inputs
VENTING
S A C O C
AGB
SFH
TGB
NRV
O F D P
LUBE UNIT
SUPPLY LINE
ALV
SCAVENGE LINE

ALV: Anti Leak Valve
EV: Eductor Valve
LOPS: Low Oil Pressure Sensor
MHX: Main Heat Exchanger
NRV: Non Return Valve
ODMS: Oil Debris Monitoring Sensor
ODMU: Oil Debris Monitoring Unit

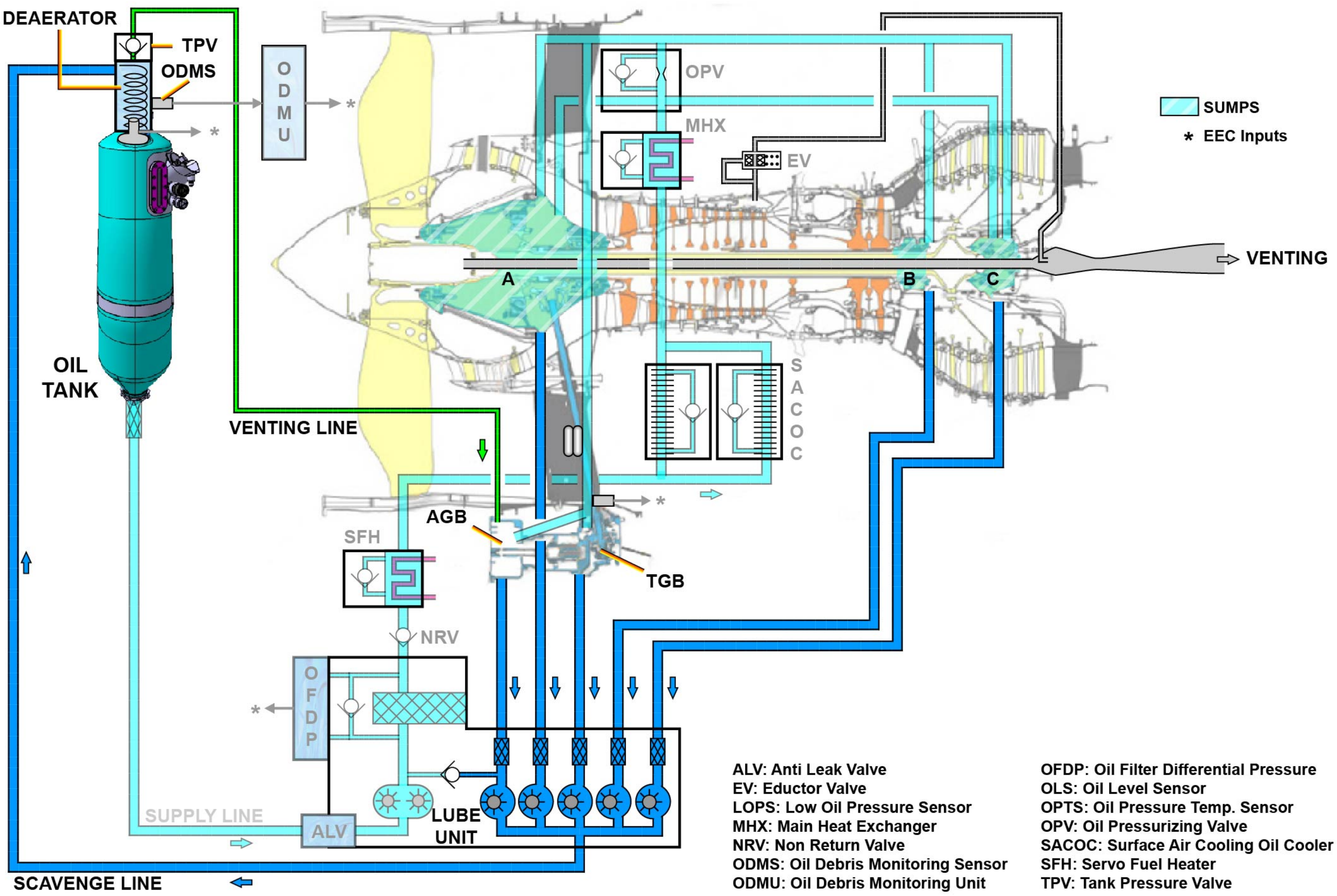
OFDP: Oil Filter Differential Pressure
OLS: Oil Level Sensor
OPTS: Oil Pressure Temp. Sensor
OPV: Oil Pressurizing Valve
SACOC: Surface Air Cooling Oil Cooler
SFH: Servo Fuel Heater
TPV: Tank Pressure Valve

OIL SUPPLY

OIL SYSTEM D/O

OIL SCAVENGE & VENTING

The engine oil scavenge system is used to return the hot lubrication oil to the tank through the Lubrication Unit.
The Lubrication Unit has five scavenge pumps that are used to pull scavenge oil from the sumps (A, B and C) and the gearboxes (TGB and AGB). To protect the scavenge pumps from large debris potentially generated within engine sumps, strainers are installed in the Lube Unit upstream each pump. A provision for magnetic chip detectors installation is also included in the strainer assemblies.
The scavenged line is connected to the oil tank through the deaerator: a static air/oil separator. It is fitted with a Tank Pressure Valve (TPV) and an Oil Debris Monitoring Sensor (ODMS).
The mist of air and oil is centrifugally separated. The oil is directed to the ODMS and then collected in the tank, whereas part of the air is used to pressurize the tank and the excess is vented to the AGB thanks to the TPV.


DEAERATOR
TPV
ODMS
*
ODMU
*
OPV
MHX
EV
SUMPS
* EEC Inputs
VENTING
A
B
C
OIL TANK
VENTING LINE
SACOC
*
AGB
TGB
SFH
NRV
OFDP
*
LUBE UNIT
SUPPLY LINE
ALV
SCAVENGE LINE

ALV: Anti Leak Valve
EV: Eductor Valve
LOPS: Low Oil Pressure Sensor
MHX: Main Heat Exchanger
NRV: Non Return Valve
ODMS: Oil Debris Monitoring Sensor
ODMU: Oil Debris Monitoring Unit
OFDP: Oil Filter Differential Pressure
OLS: Oil Level Sensor
OPTS: Oil Pressure Temp. Sensor
OPV: Oil Pressurizing Valve
SACOC: Surface Air Cooling Oil Cooler
SFH: Servo Fuel Heater
TPV: Tank Pressure Valve

OIL SCAVENGE & VENTING

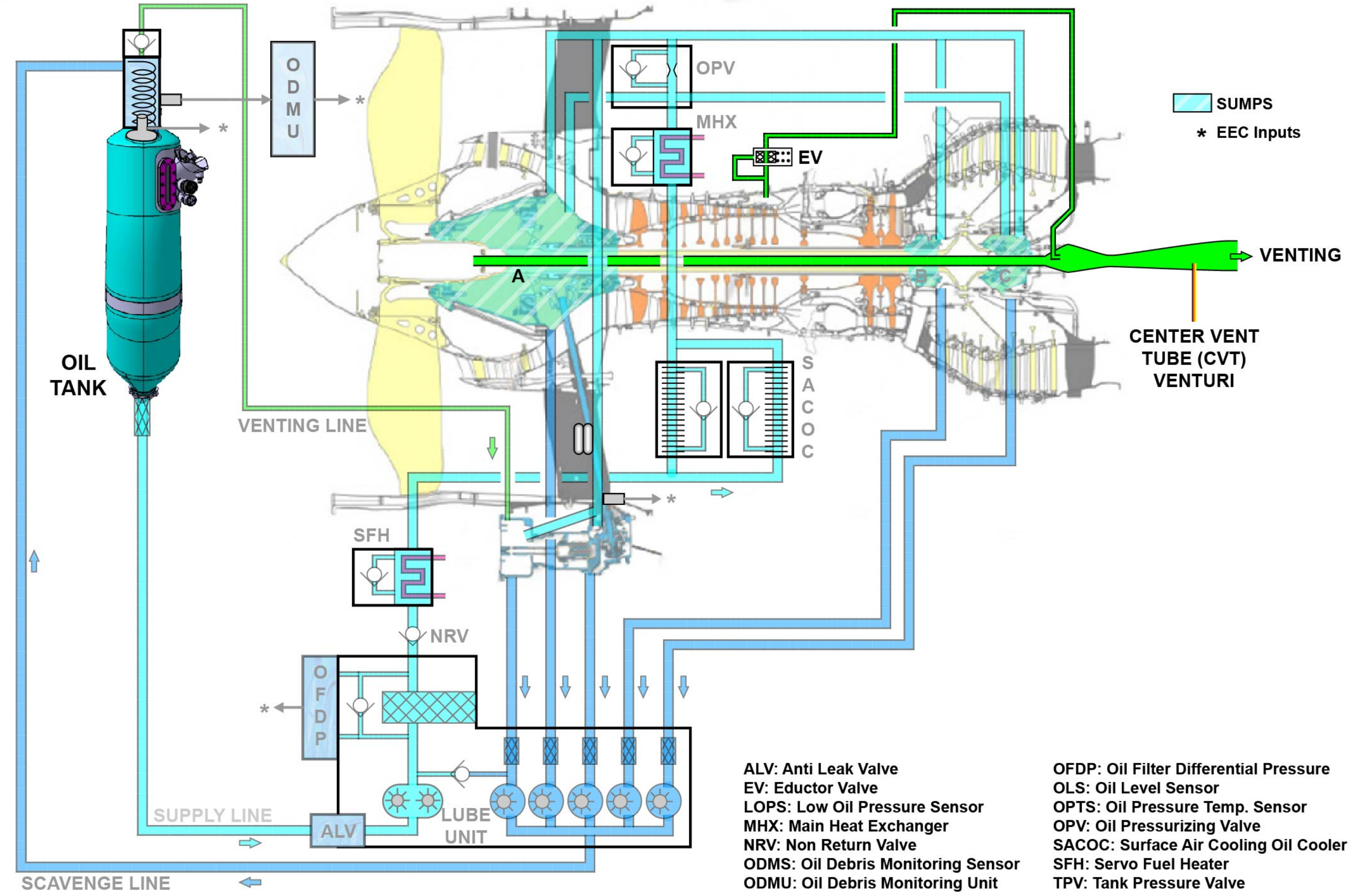
OIL SYSTEM D/O

SUMP PRESSURIZATION

Sump sealing is performed by contact carbon seals and sump pressurization is made by air pickup downstream LP Compressor (stage 25). Both are necessary to avoid oil leakage.

At low engine speed, pressure level in stage 25 is not sufficient to ensure proper A sump sealing. An Eductor Valve (EV) is therefore used to control engine A sump pressurization by providing HPC 7th stage air to an eductor tube in the Center Vent Tube (CVT) venturi in order to increase differential pressure across forward sump seals.

The EV is an inlet pressure (HPC 7) controlled, altitude compensated poppet style shutoff valve, it opens at low pressure and closes when the pressure increases.


OIL TANK
ODMU
*
VENTING LINE
SUPPLY LINE
SCAVENGE LINE
ALV
LUBE UNIT
OFDP
NRV
SFH
OPV
MHX
EV
SACOC
A
B
C
VENTING
CENTER VENT TUBE (CVT) VENTURI
SUMPS
* EEC Inputs

ALV: Anti Leak Valve
EV: Eductor Valve
LOPS: Low Oil Pressure Sensor
MHX: Main Heat Exchanger
NRV: Non Return Valve
ODMS: Oil Debris Monitoring Sensor
ODMU: Oil Debris Monitoring Unit

OFDP: Oil Filter Differential Pressure
OLS: Oil Level Sensor
OPTS: Oil Pressure Temp. Sensor
OPV: Oil Pressurizing Valve
SACOC: Surface Air Cooling Oil Cooler
SFH: Servo Fuel Heater
TPV: Tank Pressure Valve

SUMP PRESSURIZATION

OIL SYSTEM D/O

OIL MONITORING AND INDICATING

The oil monitoring and indicating system comprises:
- Oil Level (OL) indicating,
- Oil Debris Monitoring (ODM),
- Oil Pressure and Temperature (OPT) indicating,
- Low Oil Pressure (LOP) indicating,
- Oil Filter Differential Pressure (OFDP).

OIL LEVEL INDICATING

The Oil Level Sensor (OLS) is installed on the top of the oil tank.
It is of the magnetic float and reed switch type. The signal proportional to the oil level is sent to the EEC channel A.

OIL DEBRIS MONITORING

The ODMS is installed in the deaerator of the oil tank.
It is a passive, magnetic, inductive sensor. It collects ferrous particles and generates an electrical signal whose amplitude depends on particle size. The signal is processed by the ODMU and sent to the EEC channel B.

OIL PRESSURE & TEMPERATURE INDICATING

The dual OPT sensor is installed on the AGB upper front face.
It measures:
- the differential pressure between the AGB oil supply and the oil-air mixture within AGB sump and,
- the oil temperature at the AGB oil supply inlet,

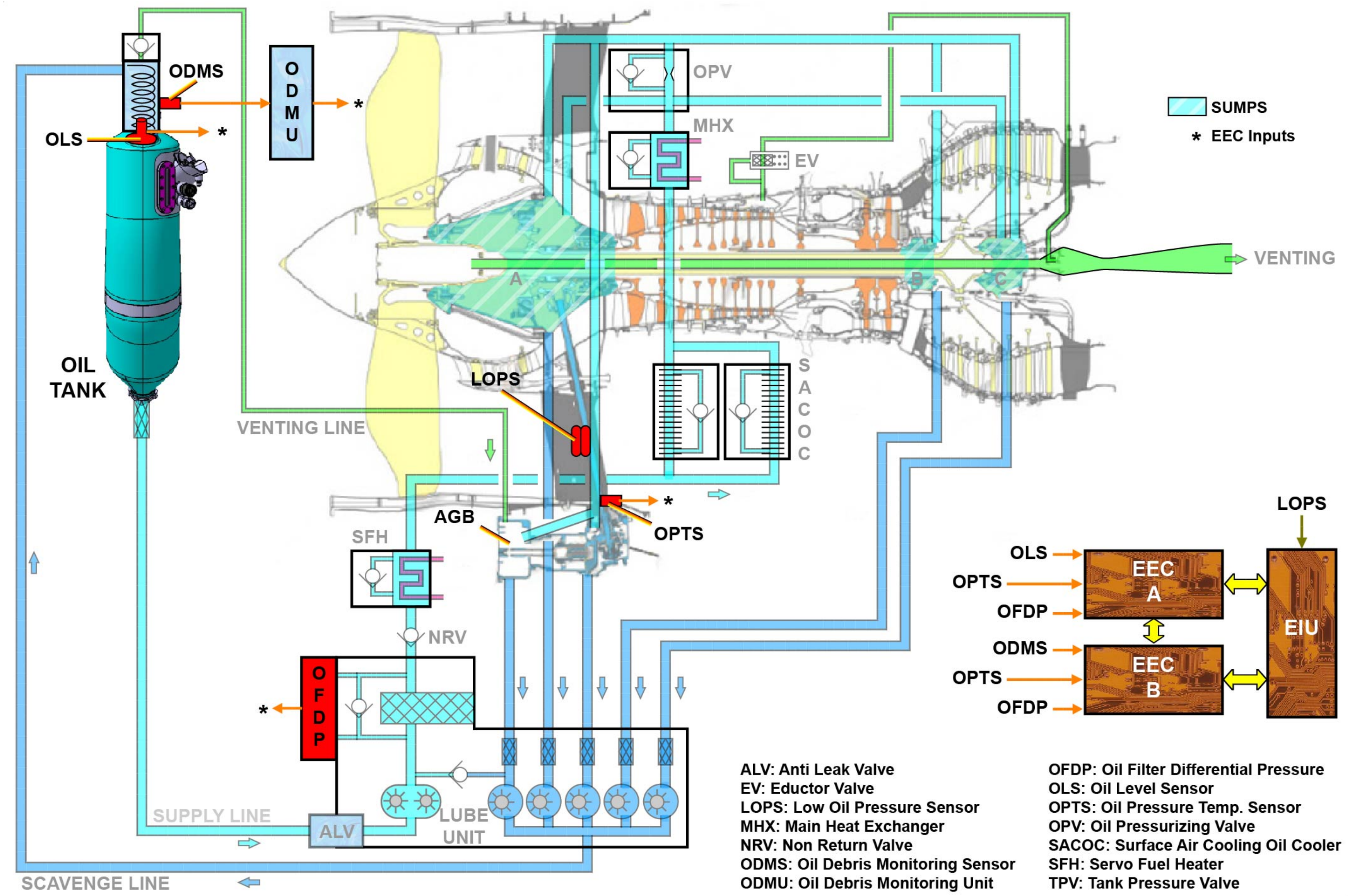
The OPT sends the signals to both EEC channels.

LOW OIL PRESSURE INDICATING

The low oil pressure switch is installed on the fan case.
It detects low oil pressure condition on the oil supply line downstream of the MHX and sends the signals to the Engine Interface Unit (EIU).

OIL FILTER DIFFERENTIAL PRESSURE

The dual OFDP sensor is installed on the Lube Unit, adjacent to the oil filter.


ODMS
OLS
*
O
D
M
U
*
OIL
TANK
VENTING LINE
OPV
MHX
EV
SUMPS
* EEC Inputs
VENTING
A
B
C
LOPS
S
A
C
O
C
AGB
*
OPTS
SFH
NRV
O
F
D
P
*
LUBE
UNIT
SUPPLY LINE
ALV
SCAVENGE LINE
LOPS
OLS
OPTS
OFDP
EEC
A
ODMS
OPTS
OFDP
EEC
B
EIU

ALV: Anti Leak Valve
EV: Eductor Valve
LOPS: Low Oil Pressure Sensor
MHX: Main Heat Exchanger
NRV: Non Return Valve
ODMS: Oil Debris Monitoring Sensor
ODMU: Oil Debris Monitoring Unit

OFDP: Oil Filter Differential Pressure
OLS: Oil Level Sensor
OPTS: Oil Pressure Temp. Sensor
OPV: Oil Pressurizing Valve
SACOC: Surface Air Cooling Oil Cooler
SFH: Servo Fuel Heater
TPV: Tank Pressure Valve

OIL MONITORING AND INDICATING - OIL LEVEL INDICATING ... OIL FILTER DIFFERENTIAL PRESSURE

ENGINE SYSTEM CONTROL AND INDICATING (3) - CFM LEAP1A

Engine Dry Crank (3)

Engine Wet Crank (3)

Engine Thrust Control (3)

Engine Automatic Start (3)

Engine Manual Start (3)

Start Fault: Starter Control Valve Failed Closed (3)

Start Fault: Hot Start (3)

Start Fault: No Light Up (3)

Oil Low Press (3)

Thrust Reverser Unlocked (3)

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OPENING AND CLOSING OF ENGINE COWL DOORS

OPENING OF THE ENGINE FAN COWL DOORS

Before working on the engine, safety precautions have to be taken.

WARNING: KEEP PERSONNEL AND EQUIPMENT CLEAR OF THE FAN COWL DOORS WHEN THE HOLD OPEN RODS ARE NOT LOCKED. THE COWL DOORS CAN CLOSE QUICKLY AND INJURY TO PERSONS OR DAMAGE TO EQUIPMENT CAN OCCUR.
DO NOT ATTEMPT TO OPEN THE FAN COWL DOORS IF THE WIND SPEED IS HIGHER THAN 74 KM/H (40 MPH).
IF THE WIND MOVES THE FAN COWL DOOR, INJURY TO PERSONS AND/OR DAMAGE TO THE ENGINE CAN OCCUR.

In the cockpit, make sure that the ENG MODE rotary selector is in the NORM position.
Make sure that the ENG MASTER 1(2) lever was in the OFF position not less than five minutes before you do this procedure.
Put WARNING NOTICE(S) in position to tell persons not to operate the ENG MODE rotary selector and the ENG MASTER 1(2) lever.
On the ENG section of maintenance panel 50VU, make sure that the ON legend of the FADEC GND PWR 1(2) pushbutton switch is off.
Put WARNING NOTICE(S) in position to tell persons not to energize FADEC 1(2).
Make sure that the slats are retracted.
Put WARNING NOTICE(S) in the cockpit to tell persons not to move the slat control lever.

CAUTION: DO NOT OPEN THE FAN COWL IF THE WING LEADING EDGE SLATS ARE EXTENDED.
DAMAGE TO THE FAN COWL, WING LEADING EDGE SLATS AND WING CAN OCCUR.

It is possible to do this task with one person, but for convenience (wind gust, fan cowl door weight), two persons are recommended.
On the engine, push the trigger to release the latch handles and pull the L1, L3 and L2 latch handles.

NOTE: When the forward latch is open, the cowl loss prevention flag is deployed on the left fan cowl door.
If the flag is not deployed on the left fan cowl door, you must examine the system for blockage.

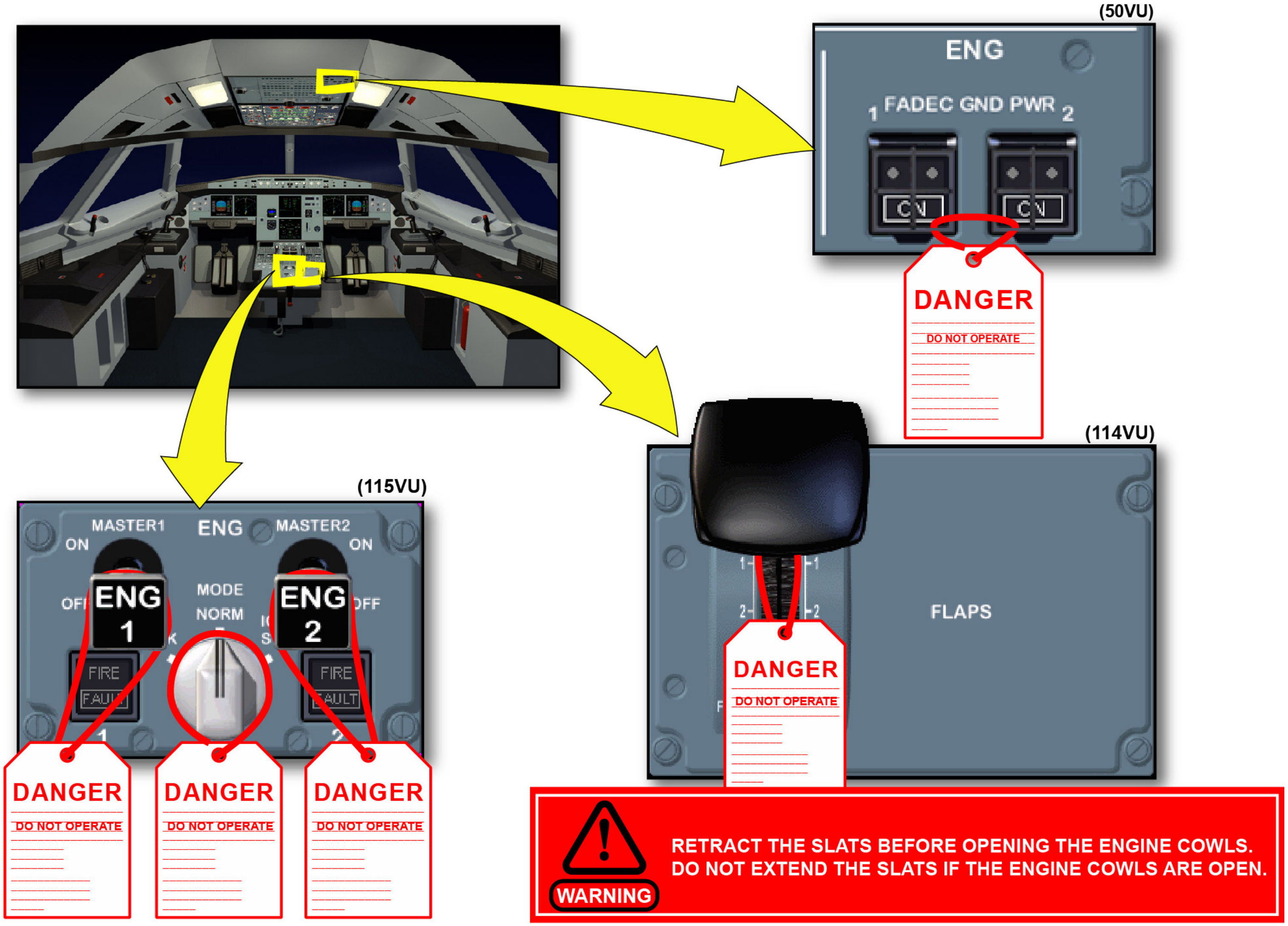
Move the Fan Cowl Door (FCD) in order to generate a gap between fan cowl door and the air intake cowl.
In the fan cowl door forward position, pull the fan cowl door in order to open it to the fully open position (53.5º).
Make sure that the front Hold Open Rod (HOR) is locked correctly (the green mark comes into view).

NOTE: The front HOR is permanently attached to the engine.

Get access to the rear HOR and move the lock ring to release the rod from its stowage bracket on the fan cowl.
Attach the rear HOR to the fitting on the engine case.
Pull the fan cowl to correctly lock the rear HOR (the green mark comes into view).

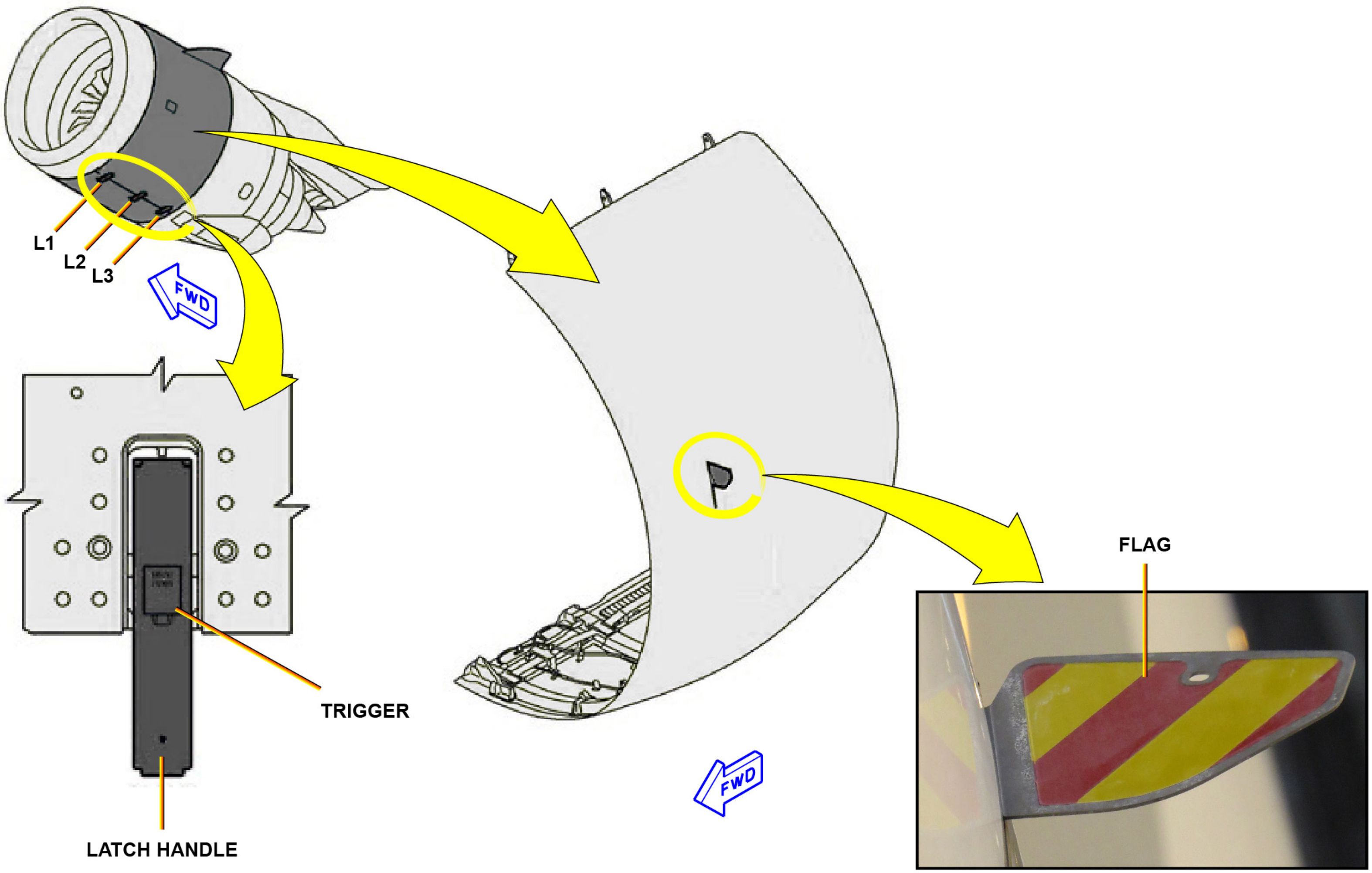
WARNING: MAKE SURE THAT EACH INDICATOR OF THE HOLD-OPEN RODS IS GREEN (LOCKED).
IF IT IS NOT GREEN, INJURY TO PERSONNEL AND DAMAGE TO EQUIPMENT CAN OCCUR.

If required, repeat this procedure for the other FCD.
Make an entry in the logbook.

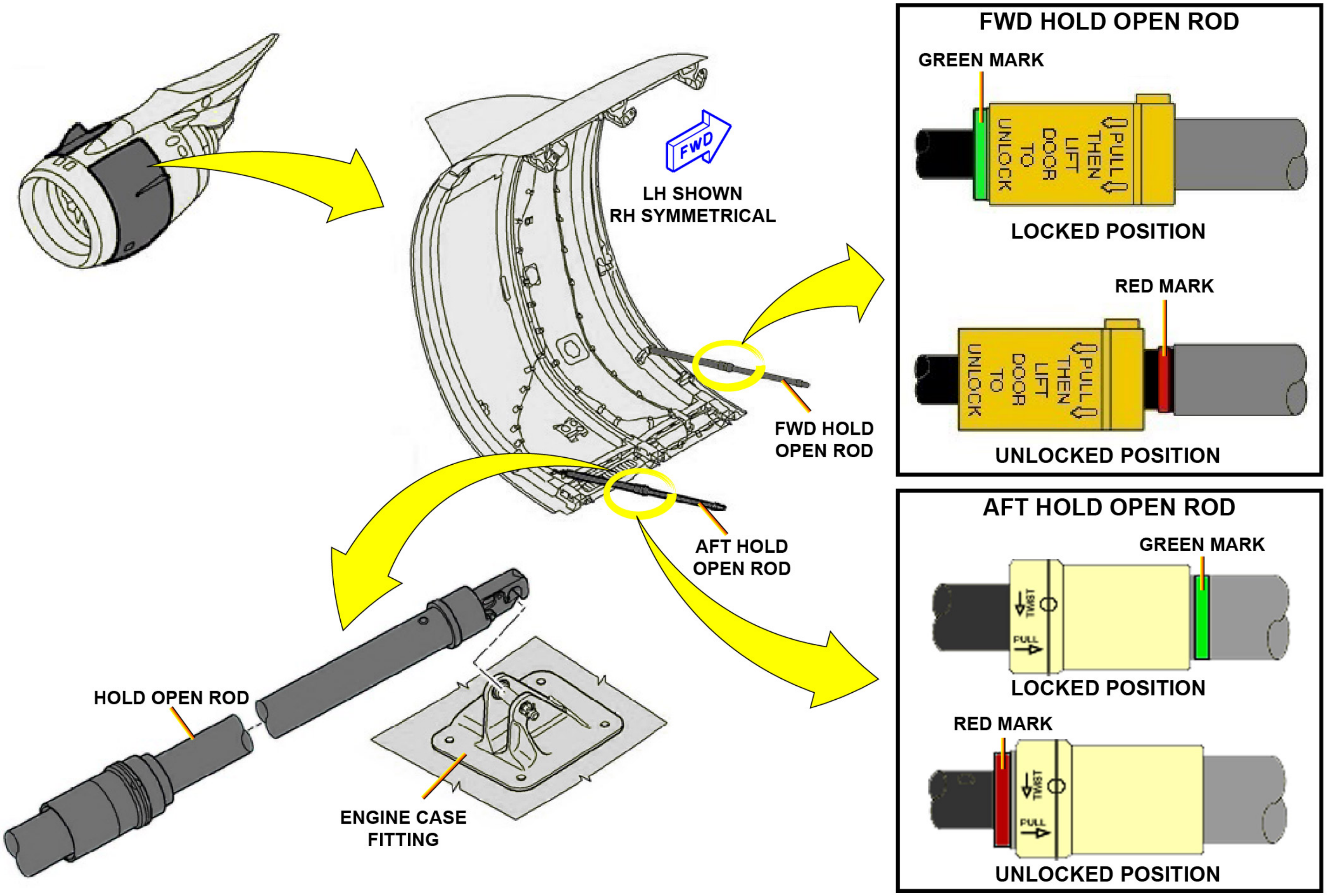

(50VU)
ENG
1 FADEC GND PWR 2
ON
ON
DANGER
DO NOT OPERATE
(114VU)
FLAPS
DANGER
DO NOT OPERATE
(115VU)
MASTER1
ENG
MASTER2
ON
ON
OFF
ENG 1
MODE
NORM
ENG 2
OFF
FIRE
FAULT
FIRE
FAULT
1
2
DANGER
DO NOT OPERATE
DANGER
DO NOT OPERATE
DANGER
DO NOT OPERATE
WARNING

RETRACT THE SLATS BEFORE OPENING THE ENGINE COWLS.
DO NOT EXTEND THE SLATS IF THE ENGINE COWLS ARE OPEN.

OPENING OF THE ENGINE FAN COWL DOORS


L1
L2
L3
FWD
TRIGGER
LATCH HANDLE
FWD
FLAG

OPENING OF THE ENGINE FAN COWL DOORS


FWD
LH SHOWN
RH SYMMETRICAL
FWD HOLD OPEN ROD
AFT HOLD OPEN ROD
HOLD OPEN ROD
ENGINE CASE FITTING
FWD HOLD OPEN ROD
GREEN MARK
PULL THEN LIFT DOOR TO UNLOCK
LOCKED POSITION
RED MARK
PULL THEN LIFT DOOR TO UNLOCK
UNLOCKED POSITION
AFT HOLD OPEN ROD
GREEN MARK
TWIST
PULL
LOCKED POSITION
RED MARK
TWIST
PULL
UNLOCKED POSITION

OPENING OF THE ENGINE FAN COWL DOORS

OPENING AND CLOSING OF ENGINE COWL DOORS

OPENING OF THE ENGINE THRUST REVERSER COWL DOORS

Do the deactivation of the thrust reverser system for maintenance: On the Isolation Control Unit (ICU), move and secure the lever to the INHIBITED position.
At 6 o'clock position, open the two Latch Access Doors.
Open the latches in sequence: L1, L2, L3.1, L3.2, L4.1, L4.2, LACC-1 and LACC-2.

NOTE: LACC = Latch Aft Core Cowl

CAUTION: DO NOT OPEN THE THRUST REVERSER COWLS WHEN THE TRANSLATING COWL IS DEPLOYED. DO NOT DEPLOY THE TRANSLATING COWL WHEN THRUST REVERSER COWLS ARE OPEN. IF YOU DO NOT OBEY THESE INSTRUCTIONS, THE THRUST REVERSER COWLS CAN TOUCH THE WING AND DAMAGE CAN OCCUR.

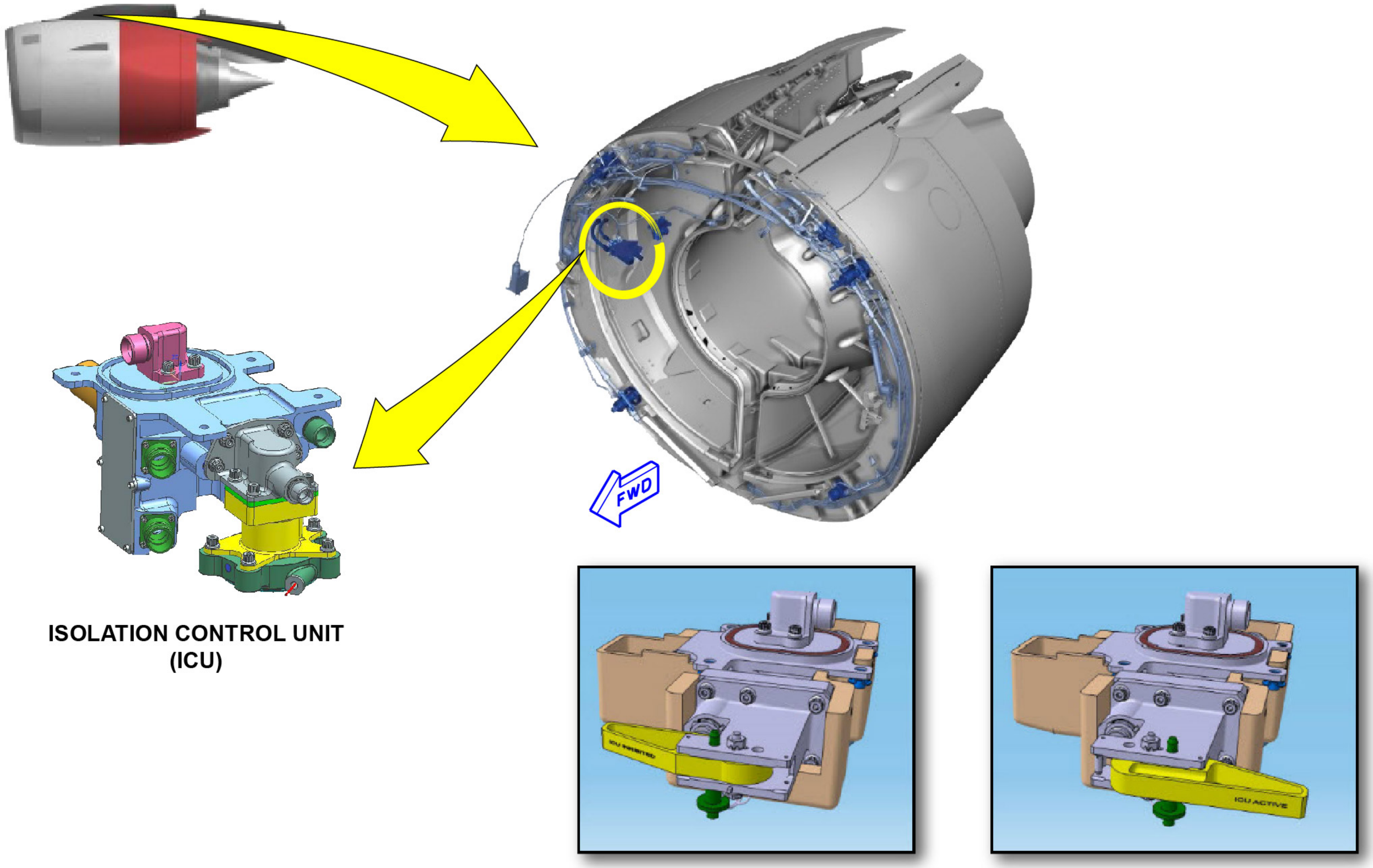
Connect the hand pump flexible hose to the opening actuator connection fitting and operate the pump until the actuator opens the thrust reverser cowl to 25º.

NOTE: The opening actuator is fitted with a pressure indicator that extrudes when pressurized.

Release and extend the Hold Open Rod.
Adjust it as necessary and attach it to the HOR engine support bracket.
Operate the pump until the HOR is autolocked.
Make sure that the HOR is completely extended and correctly locked (green band visible).

NOTE: The Thrust Reverser Cowl fully open position is 45º.

Manually release the pressure from the actuator.
If necessary, repeat the sequence to open the other Thrust Reverser Cowl.

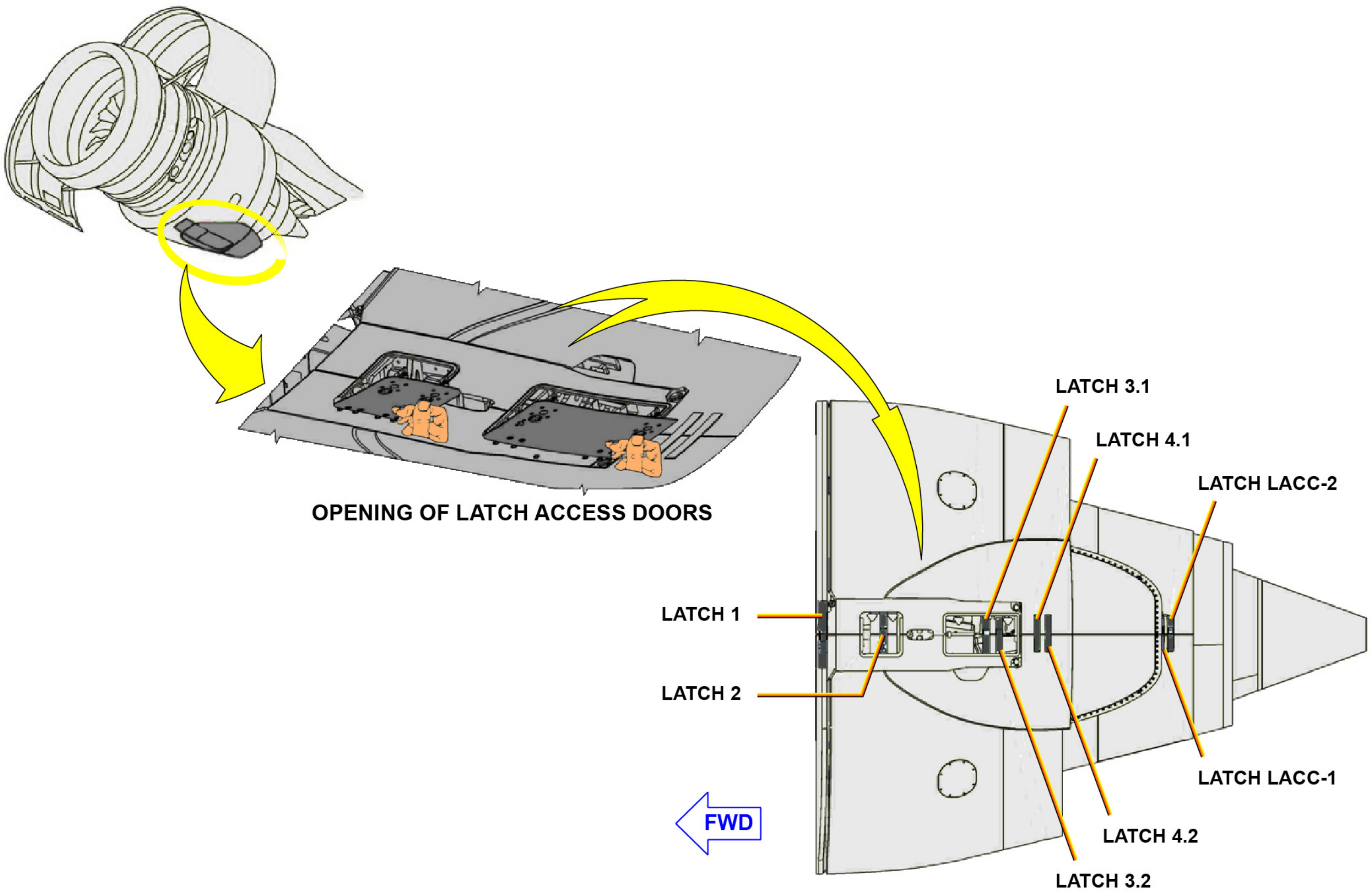


ISOLATION CONTROL UNIT (ICU)

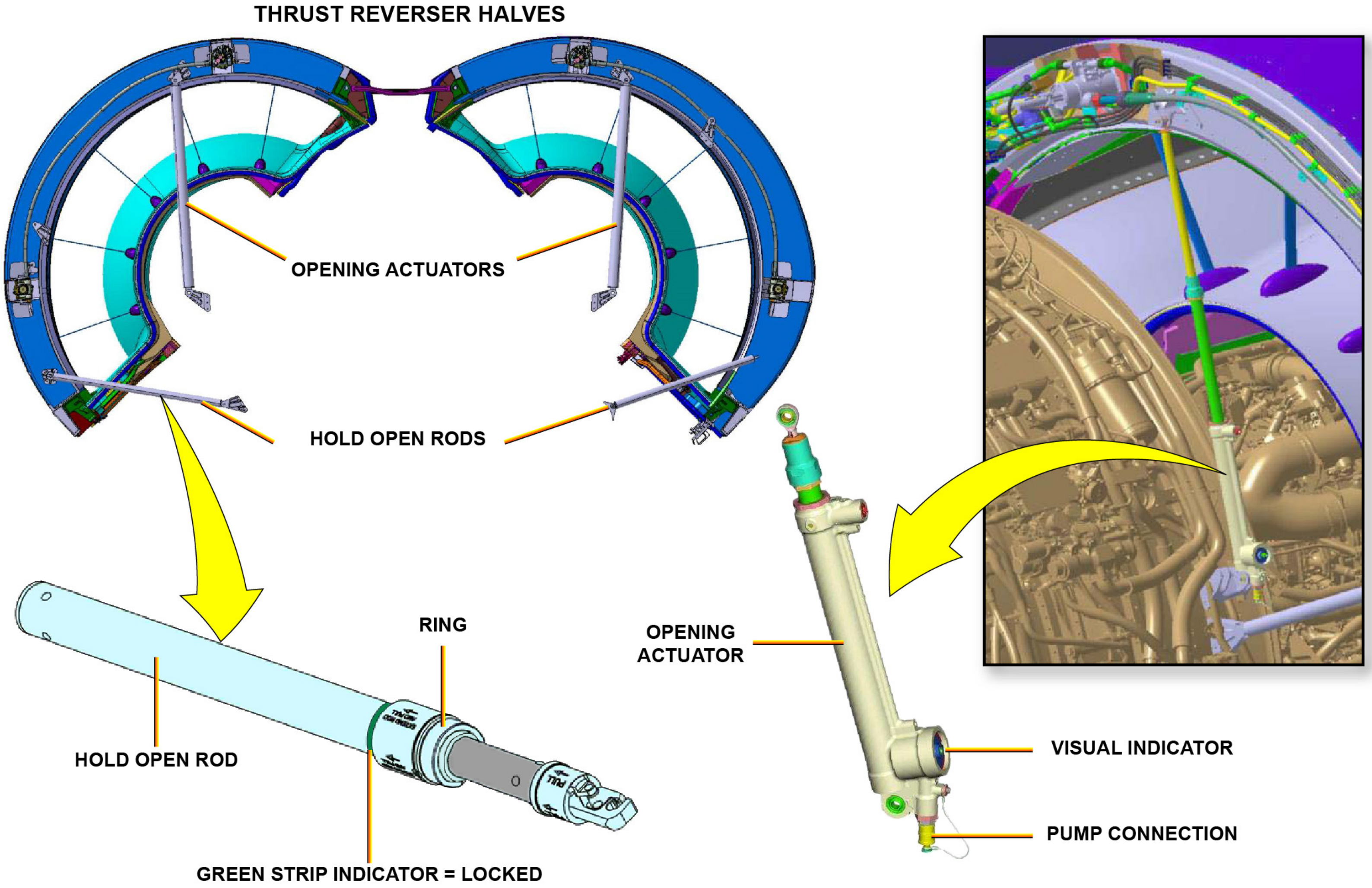
THRUST REVERSER INHIBITED

THRUST REVERSER ACTIVE

OPENING OF THE ENGINE THRUST REVERSER COWL DOORS


OPENING OF LATCH ACCESS DOORS
LATCH 3.1
LATCH 4.1
LATCH LACC-2
LATCH 1
LATCH 2
LATCH LACC-1
FWD
LATCH 4.2
LATCH 3.2

OPENING OF THE ENGINE THRUST REVERSER COWL DOORS

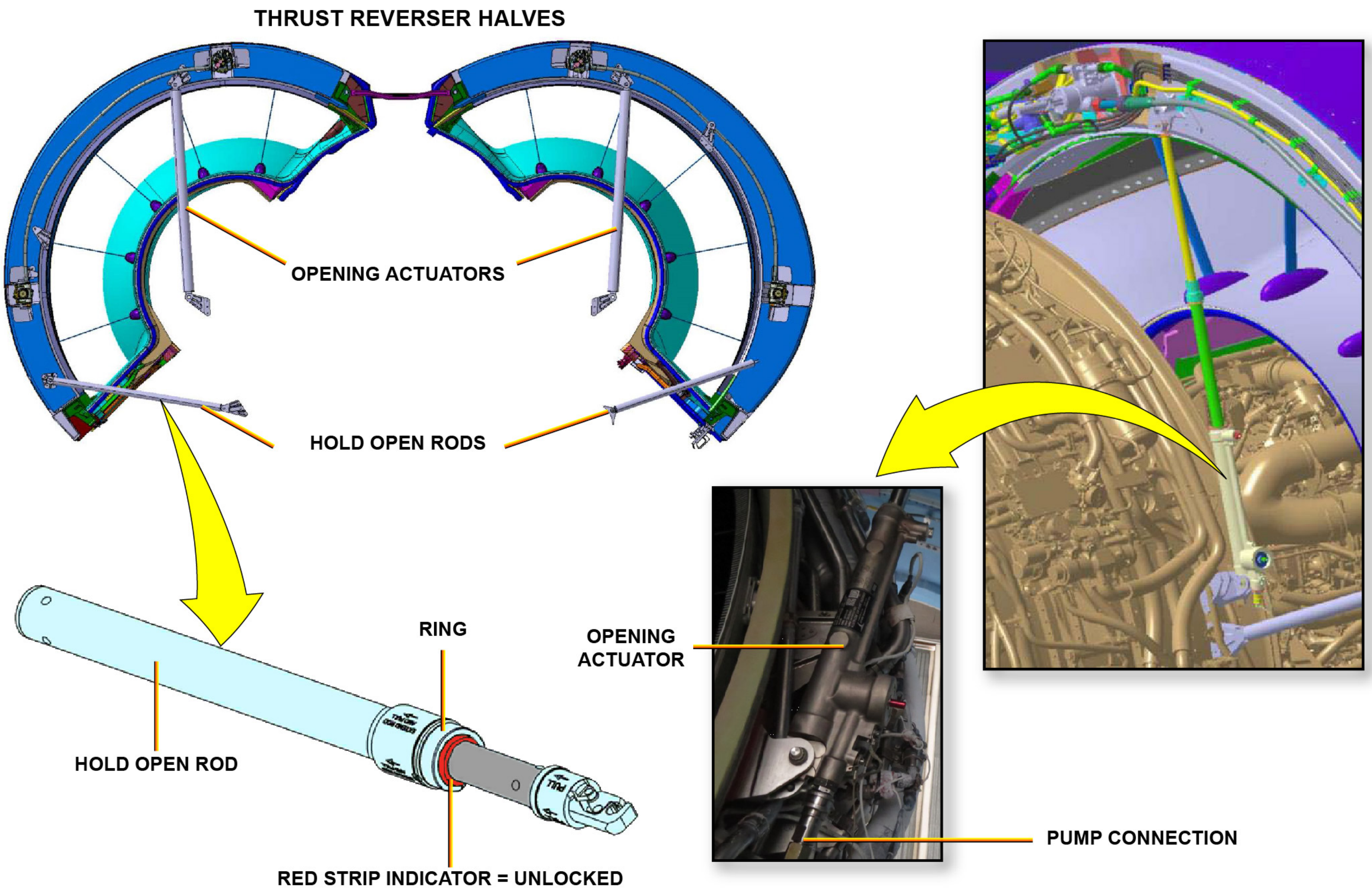

THRUST REVERSER HALVES
OPENING ACTUATORS
HOLD OPEN RODS
RING
OPENING ACTUATOR
HOLD OPEN ROD
GREEN STRIP INDICATOR = LOCKED
VISUAL INDICATOR
PUMP CONNECTION

OPENING OF THE ENGINE THRUST REVERSER COWL DOORS

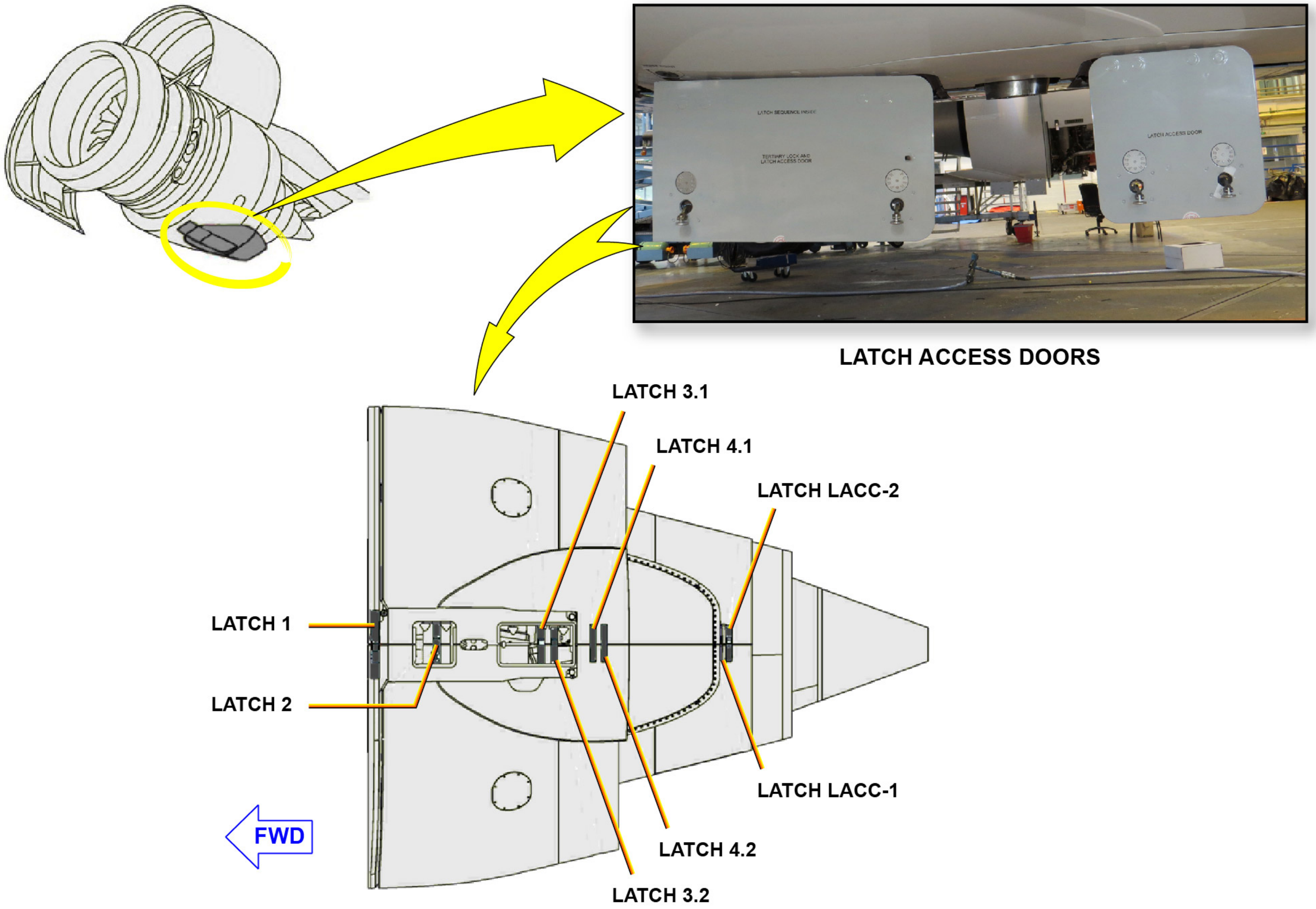
OPENING AND CLOSING OF ENGINE COWL DOORS

CLOSING OF THE ENGINE THRUST REVERSER COWL DOORS

Pay attention of the warnings and cautions mentioned for Fan and Thrust Reverser cowls opening.
Make sure that you did the deactivation of the thrust reverser system for maintenance.
Connect the hand pump flexible hose to the opening actuator connection fitting and operate the pump to unload the Hold Open Rod.
Move the ring to unlock the HOR and visually check that the red strip indicator is visible.
Connect the HOR to its storage fitting.
Manually release the pressure from the actuator to close the cowl. If necessary, repeat the operation with the other cowl.
Close the thrust reverser cowl latches in the sequence that follows: LACC-2, LACC-1, L4.1, L4.2, L3.2, L3.1, L2 and L1.
Close the two Latch Access Doors.
Make sure that the work area is clean and clear of tool(s) and other items.
Do the reactivation of the thrust reverser system for maintenance: on the ICU, move and secure the lever to the ACTIVE position.


THRUST REVERSER HALVES
OPENING ACTUATORS
HOLD OPEN RODS
RING
OPENING ACTUATOR
HOLD OPEN ROD
RED STRIP INDICATOR = UNLOCKED
PUMP CONNECTION

CLOSING OF THE ENGINE THRUST REVERSER COWL DOORS


LATCH ACCESS DOORS
LATCH 3.1
LATCH 4.1
LATCH LACC-2
LATCH 1
LATCH 2
LATCH LACC-1
LATCH 4.2
LATCH 3.2
FWD

CLOSING OF THE ENGINE THRUST REVERSER COWL DOORS

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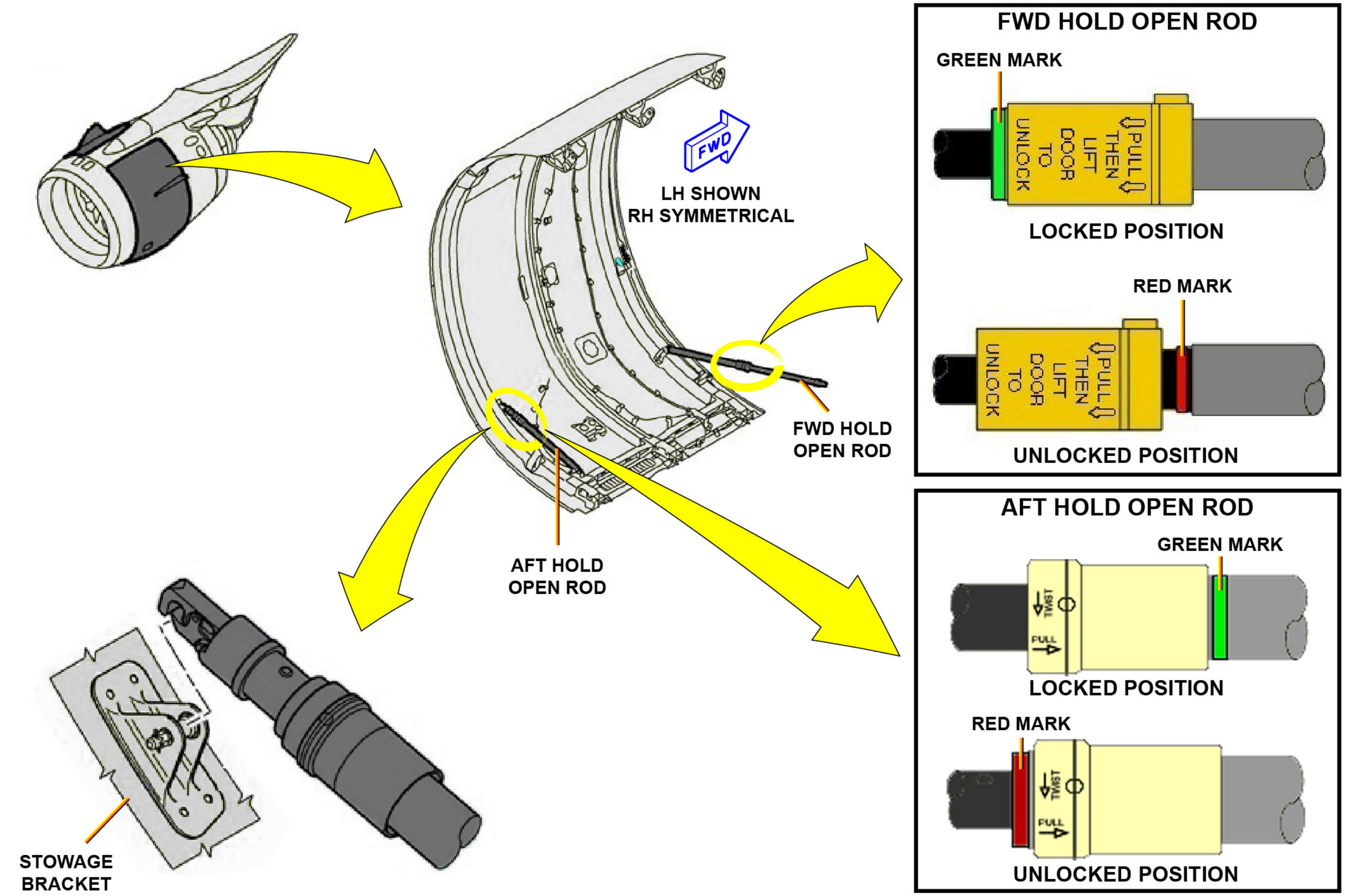
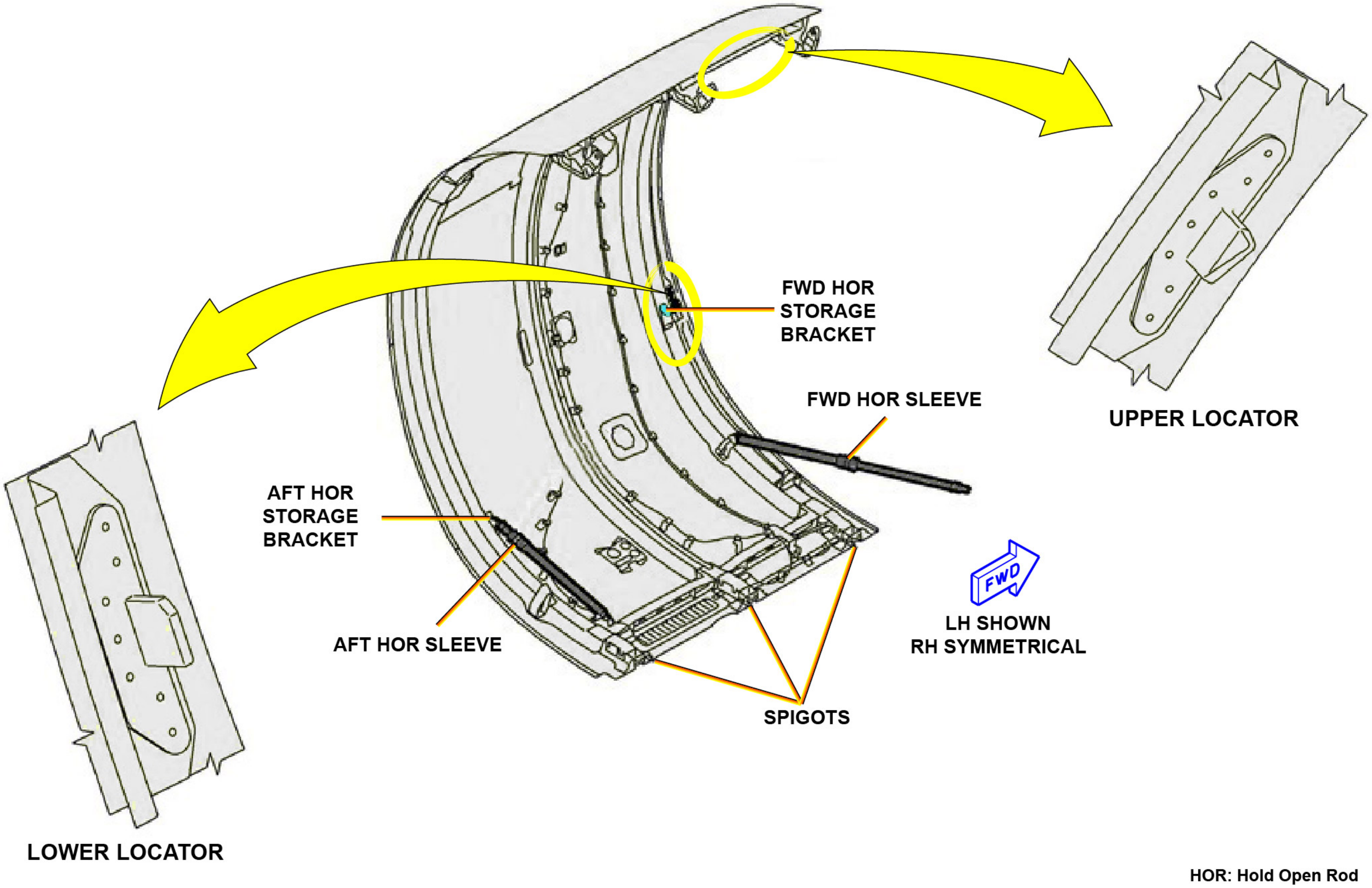
OPENING AND CLOSING OF ENGINE COWL DOORS

CLOSING OF THE ENGINE FAN COWL DOORS

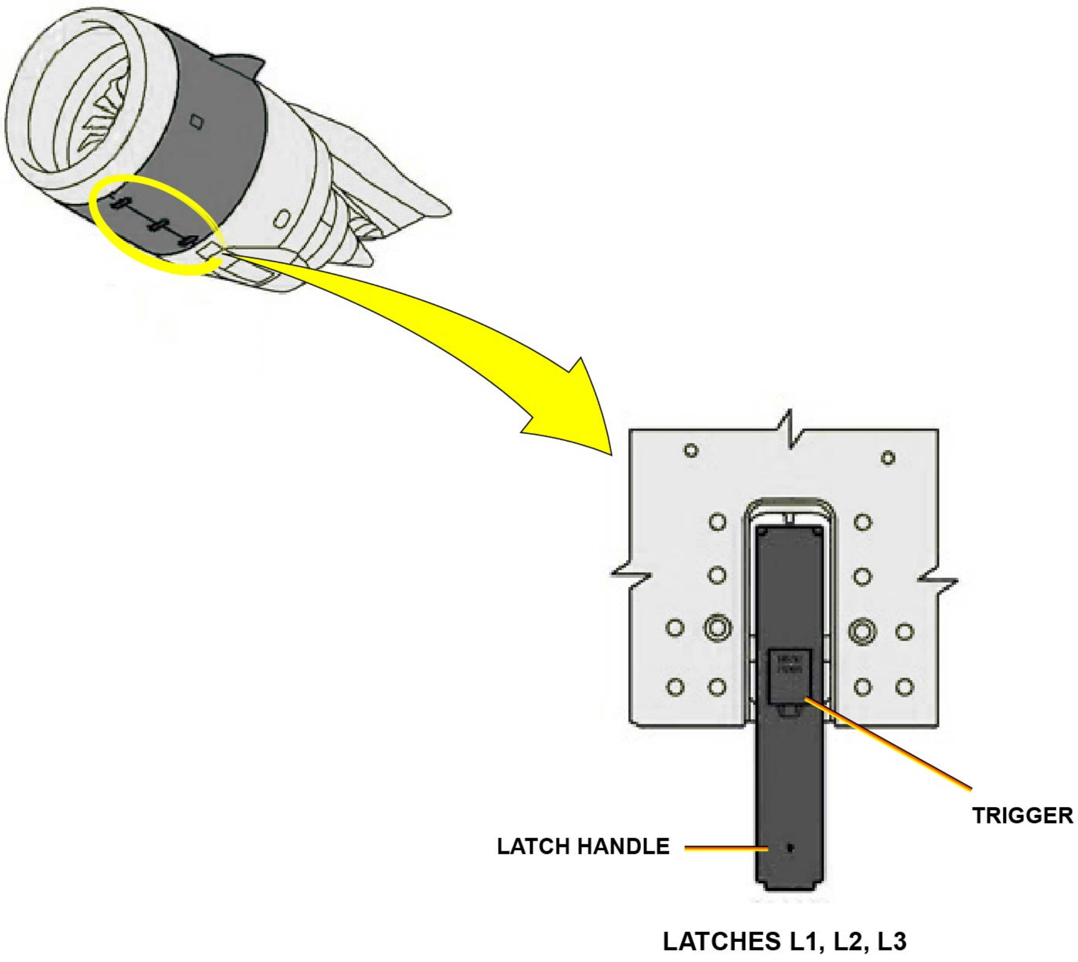
Manually lift and hold the left fan cowl door at the lower edge so that the weight is not on the Hold Open Rods (HOR).
Move the attachment lock on the rear HOR to release it from the fitting on the engine.
Stow the rear HOR to the stowage bracket located on the fan cowl door.
From the outside of the forward fan area, secure the FCD with one hand and unlock the primary lock of the front HOR (red band visible on the middle sleeve).
Lift the FCD to unlock the secondary lock.
Carefully lower the FCD to the closed position.
Push on the fan cowl door to engage the spigots and the front upper and lower locators.
If necessary, repeat the operation for the other FCD.
Engage and push each latch handle in sequence: L2, L3 and L1.
On the left fan cowl door, make sure that the flag is fully retracted inside its receptacle.
Make a record in the aircraft logbook to tell that you closed the fan cowl doors.
The proximity sensors installed on the latch keepers detect improper latching and trigger the relative ECAM indication.


FWD HOLD OPEN ROD
GREEN MARK
PULL THEN LIFT DOOR TO UNLOCK
LOCKED POSITION
RED MARK
PULL THEN LIFT DOOR TO UNLOCK
UNLOCKED POSITION
AFT HOLD OPEN ROD
GREEN MARK
TWIST
PULL
LOCKED POSITION
RED MARK
TWIST
PULL
UNLOCKED POSITION
FWD
LH SHOWN
RH SYMMETRICAL
FWD HOLD
OPEN ROD
AFT HOLD
OPEN ROD
STOWAGE
BRACKET

CLOSING OF THE ENGINE FAN COWL DOORS


FWD HOR
STORAGE
BRACKET
FWD HOR SLEEVE
UPPER LOCATOR
AFT HOR
STORAGE
BRACKET
AFT HOR SLEEVE
FWD
LH SHOWN
RH SYMMETRICAL
SPIGOTS
LOWER LOCATOR
HOR: Hold Open Rod

CLOSING OF THE ENGINE FAN COWL DOORS

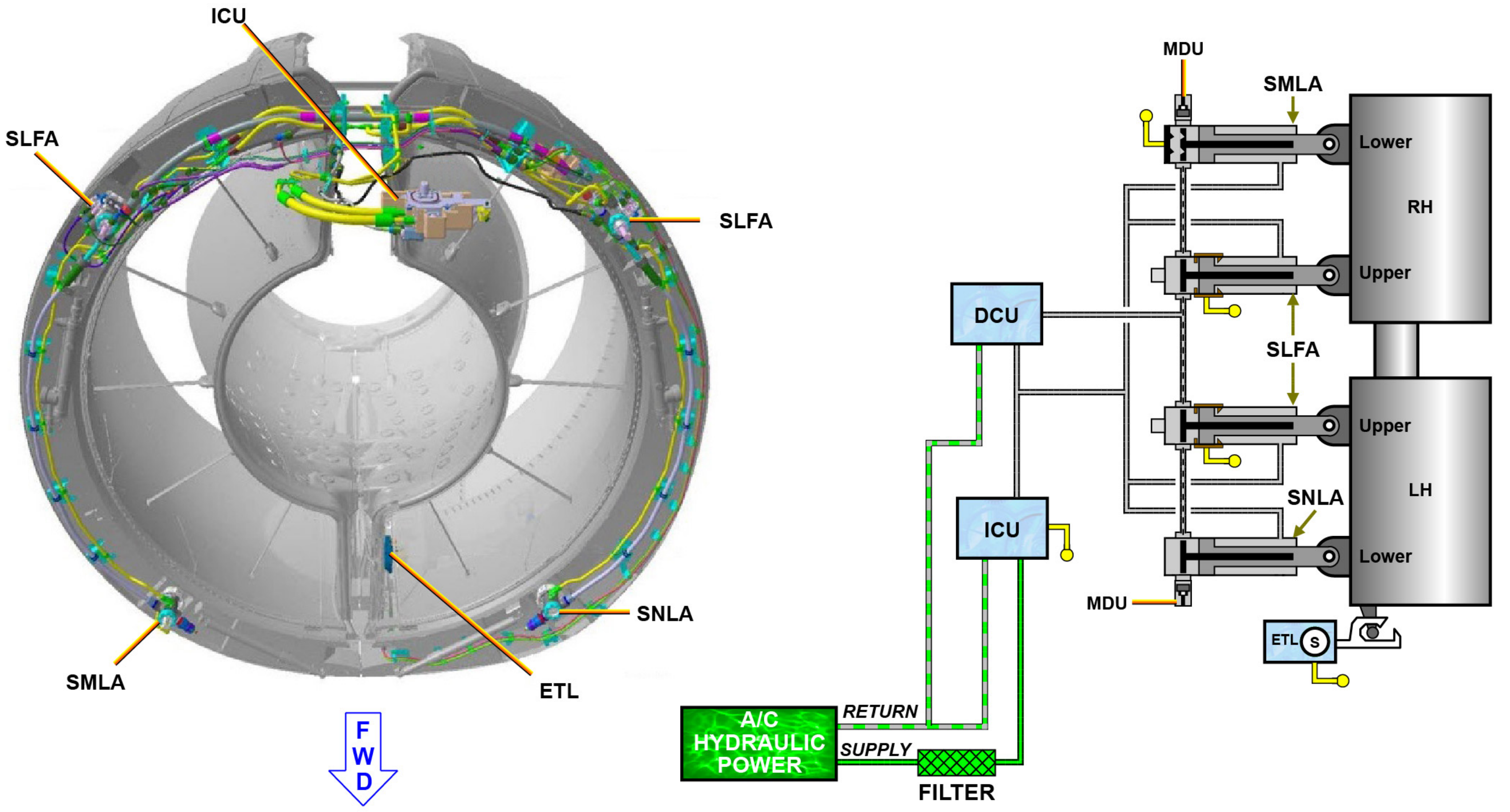

TRIGGER
LATCH HANDLE
LATCHES L1, L2, L3

CLOSING OF THE ENGINE FAN COWL DOORS

THRUST REVERSER HANDLING (2/3)

T/R MAINTENANCE PRACTICES & DEACTIVATION / REACTIVATION MAIN ELEMENTS

The Thrust Reverser main elements for Maintenance Practices & Deactivation / Reactivation are the Isolation Control Unit (ICU), Synchronized Locking Feedback Actuators (SLFAs), Synchronized Manual Locking Actuator (SMLA) with its Manual Drive Unit (MDU), Synchronized Non Locking Actuator (SNLA) with its MDU, Electric Tertiary Lock (ETL) and the inhibition pin.


ICU
SLFA
SLFA
SNLA
SMLA
ETL
F
W
D
MDU
SMLA
Lower
RH
Upper
DCU
SLFA
Upper
LH
SNLA
ICU
Lower
MDU
ETL
S
A/C
HYDRAULIC
POWER
RETURN
SUPPLY
FILTER

- - - : Synchro system
DCU: Directional Control Unit
ETL: Electric Tertiary Lock
ICU: Isolation Control Unit
MDU: Manual Drive Unit
SLFA: Synchronized Locking Feedback Actuator
SMLA: Synchronized Manual Locking Actuator
SNLA: Synchronized Non Locking Actuator

T/R MAINTENANCE PRACTICES & DEACTIVATION / REACTIVATION MAIN ELEMENTS

THRUST REVERSER HANDLING (2/3)

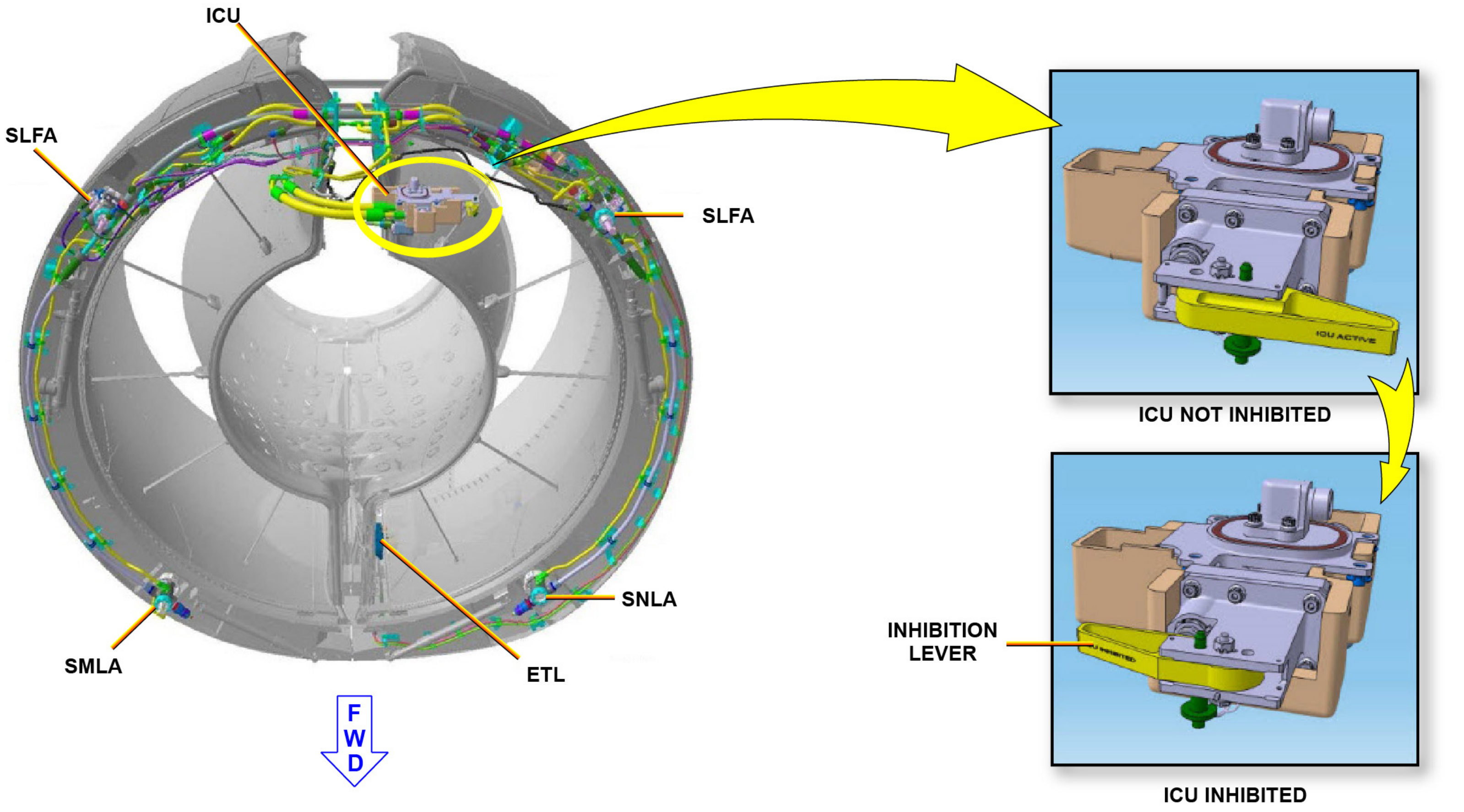
THRUST REVERSER DEACTIVATION AND LOCKOUT

Thrust reverser deactivation for ground maintenance:

- Apply the applicable safety precautions.
- Turn the inhibit lever to the inhibited position and secure it with the lockout pin.

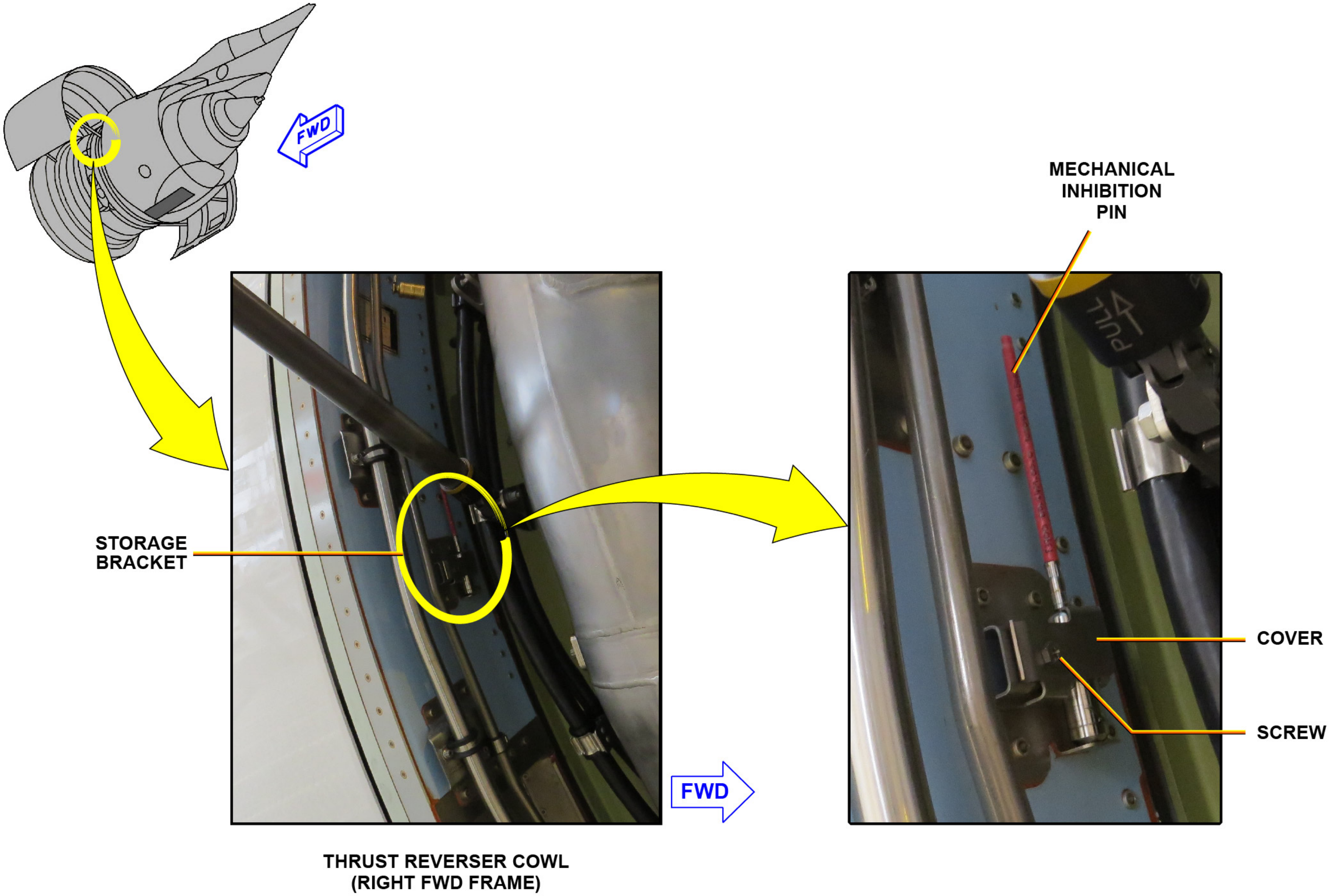
Thrust reverser deactivation for flight:

- Apply the applicable safety precautions.
- Do the Thrust Reverser deactivation for ground maintenance.
- Install the translating sleeve lockout pin.
- Check for the Thrust Reverser deactivation warning on the EWD.
- Make the corresponding entry in the logbook and put a warning notice in the cockpit.

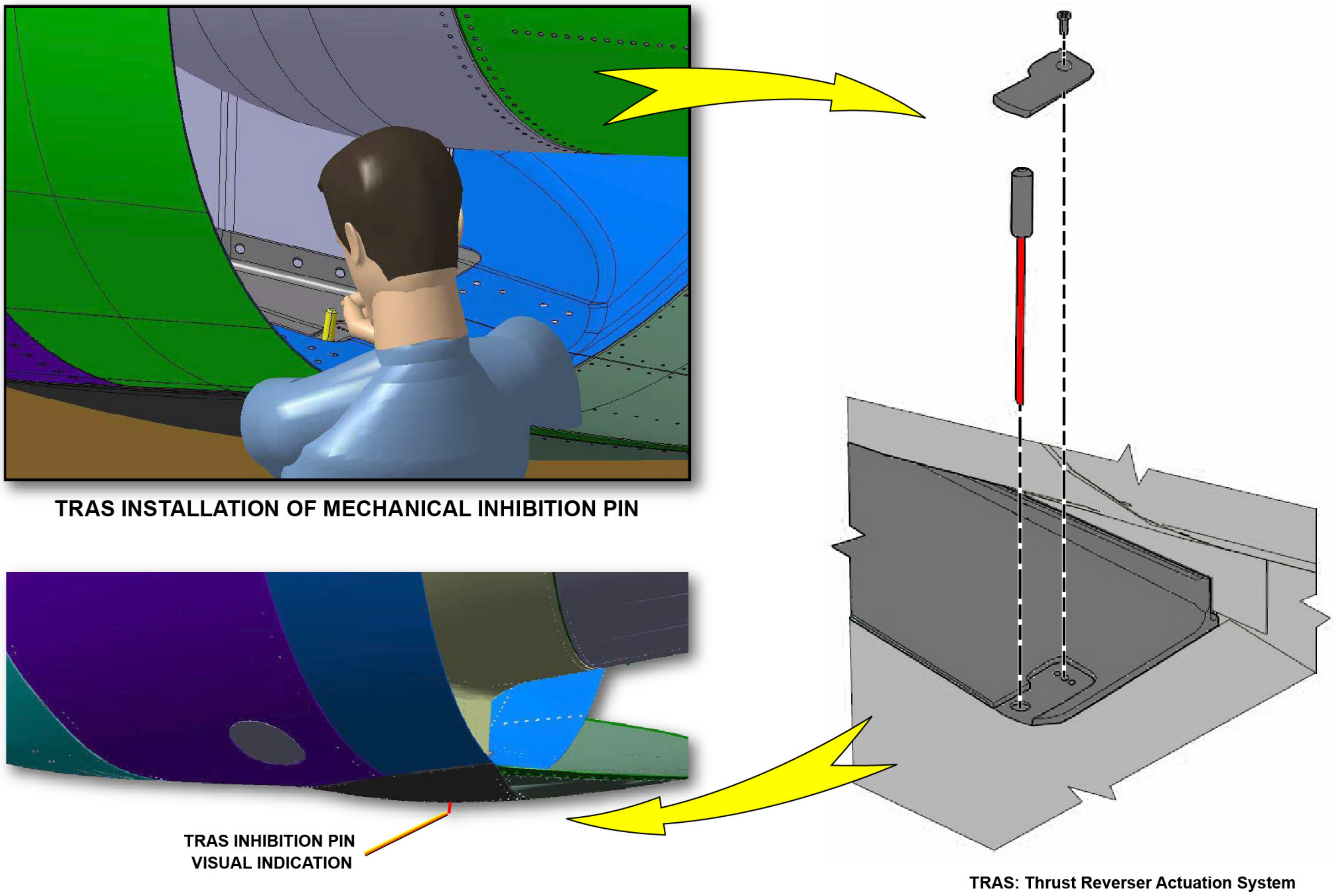

ICU
SLFA
SLFA
SNLA
SMLA
ETL
F
W
D
ICU ACTIVE
ICU NOT INHIBITED
INHIBITION LEVER
INHIBITED
ICU INHIBITED

ETL: Electric Tertiary Lock
ICU: Isolation Control Unit
MDU: Manual Drive Unit
SLFA: Synchronized Locking Feedback Actuator
SMLA: Synchronized Manual Locking Actuator
SNLA: Synchronized Non Locking Actuator

THRUST REVERSER DEACTIVATION AND LOCKOUT


FWD
MECHANICAL INHIBITION PIN
STORAGE BRACKET
COVER
SCREW
FWD
THRUST REVERSER COWL (RIGHT FWD FRAME)

THRUST REVERSER DEACTIVATION AND LOCKOUT



TRAS INSTALLATION OF MECHANICAL INHIBITION PIN

TRAS INHIBITION PIN VISUAL INDICATION

TRAS: Thrust Reverser Actuation System

THRUST REVERSER DEACTIVATION AND LOCKOUT

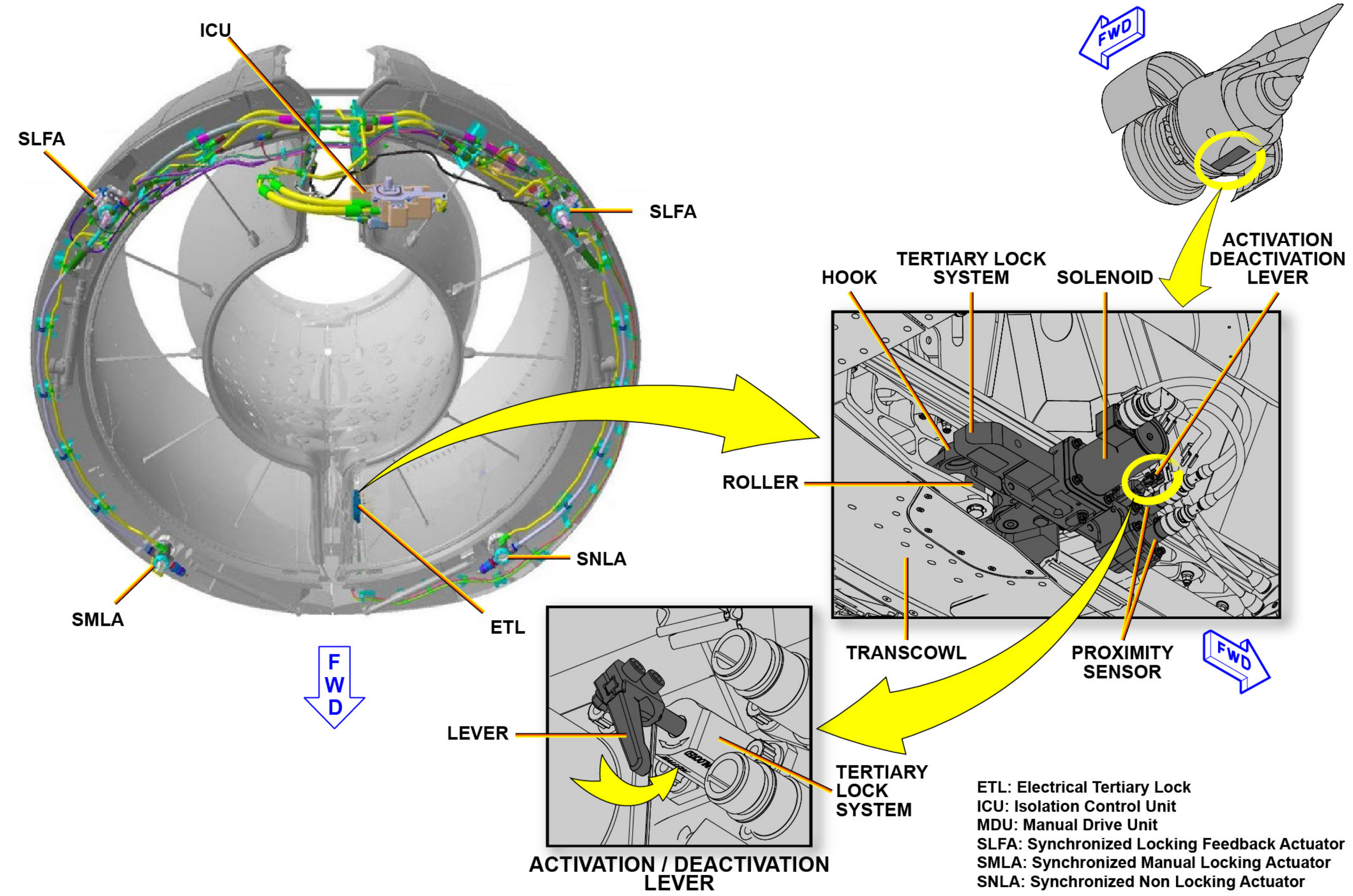
THRUST REVERSER HANDLING (2/3)

MAINTENANCE PRACTICES ON T/ R TRANSLATING SLEEVES

Manual extension of the thrust reverser translating sleeves:

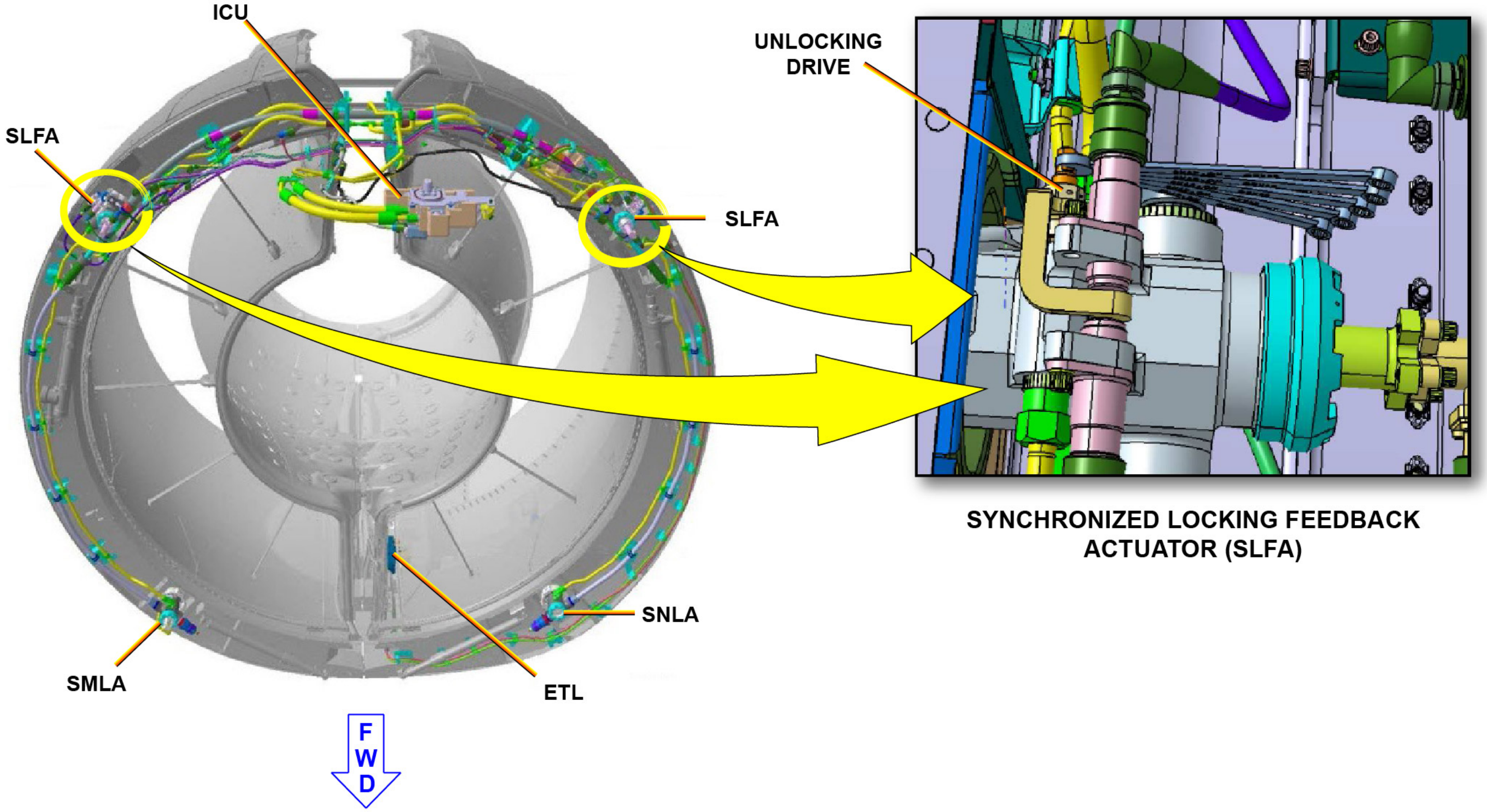
- Apply the applicable safety precautions,
- Open the fan cowl doors,
- Do the deactivation of the thrust reverser system for maintenance,
- Do the deactivation of the ETL with the deactivation lever.
- Unlock the SLFA primary locks on both sides,
- Manually deploy the translating sleeves by turning one MDU drive clockwise with a 3/8 inch square drive tool,
- Secure the T/R translating sleeves with the SMLA locking handle.

NOTE: The SMLA locking procedure is only done during maintenance. When the maintenance is complete, you must do the unlocking procedure. Never permit flight with a synchronized manual locking actuator in the locked condition.
MDU drive tool characteristics: max speed 400 rpm, max torque 5 Nm (3.7 lbf.ft).


ICU
SLFA
SLFA
SNLA
SMLA
ETL
FWD
FWD
FWD
HOOK
TERTIARY LOCK SYSTEM
SOLENOID
ACTIVATION DEACTIVATION LEVER
ROLLER
TRANSCOWL
PROXIMITY SENSOR
LEVER
TERTIARY LOCK SYSTEM
ACTIVATION / DEACTIVATION LEVER

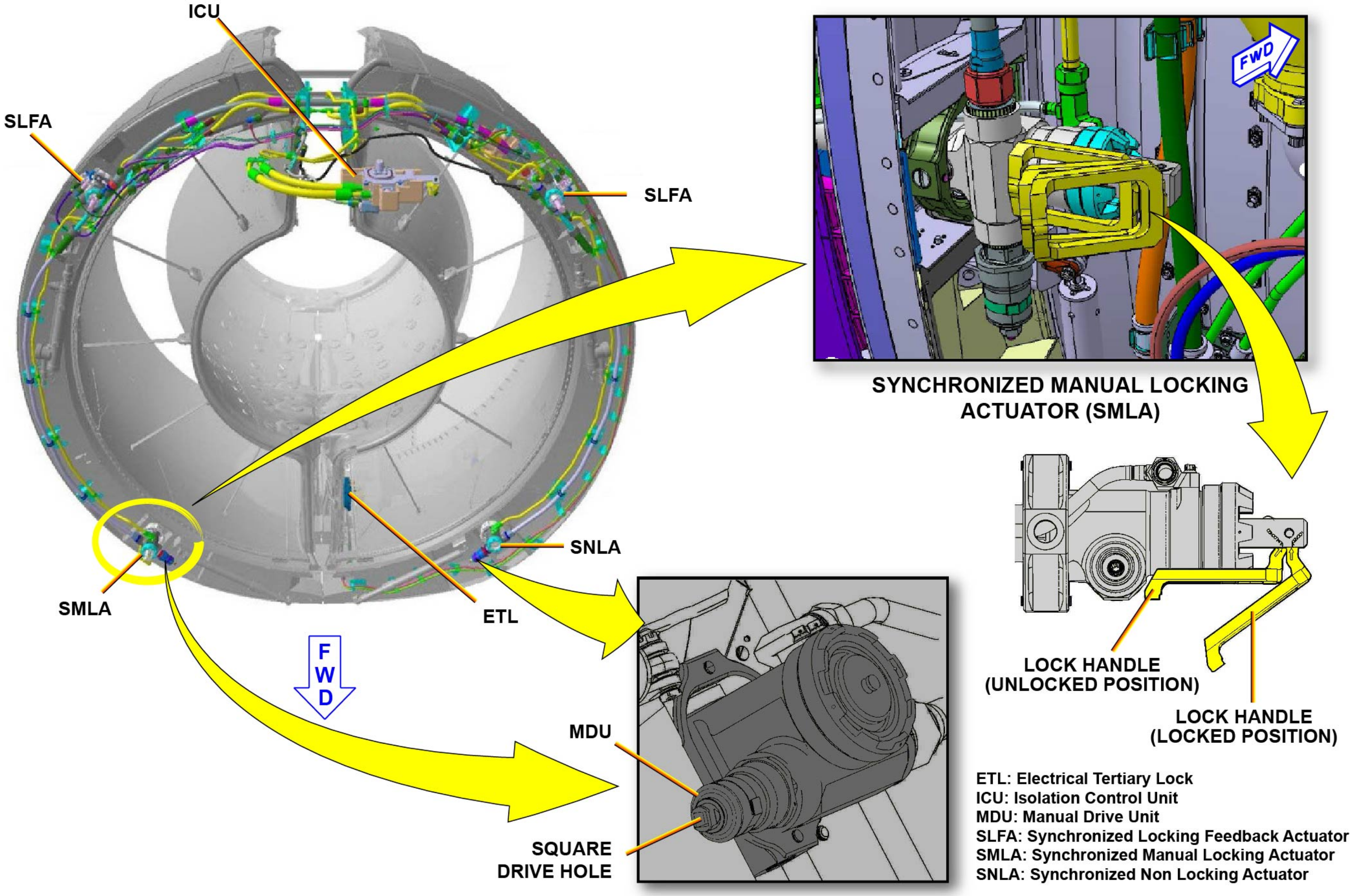
ETL: Electrical Tertiary Lock
ICU: Isolation Control Unit
MDU: Manual Drive Unit
SLFA: Synchronized Locking Feedback Actuator
SMLA: Synchronized Manual Locking Actuator
SNLA: Synchronized Non Locking Actuator

MAINTENANCE PRACTICES ON T/ R TRANSLATING SLEEVES


ICU
UNLOCKING
DRIVE
SLFA
SLFA
SNLA
SMLA
ETL
SYNCHRONIZED LOCKING FEEDBACK
ACTUATOR (SLFA)
F
W
D

ETL: Electrical Tertiary Lock
ICU: Isolation Control Unit
MDU: Manual Drive Unit
SLFA: Synchronized Locking Feedback Actuator
SMLA: Synchronized Manual Locking Actuator
SNLA: Synchronized Non Locking Actuator

MAINTENANCE PRACTICES ON T/ R TRANSLATING SLEEVES


ICU
SLFA
SLFA
SNLA
SMLA
ETL
FWD
FWD
MDU
SQUARE DRIVE HOLE
SYNCHRONIZED MANUAL LOCKING ACTUATOR (SMLA)
LOCK HANDLE (UNLOCKED POSITION)
LOCK HANDLE (LOCKED POSITION)

ETL: Electrical Tertiary Lock
ICU: Isolation Control Unit
MDU: Manual Drive Unit
SLFA: Synchronized Locking Feedback Actuator
SMLA: Synchronized Manual Locking Actuator
SNLA: Synchronized Non Locking Actuator

MAINTENANCE PRACTICES ON T/ R TRANSLATING SLEEVES

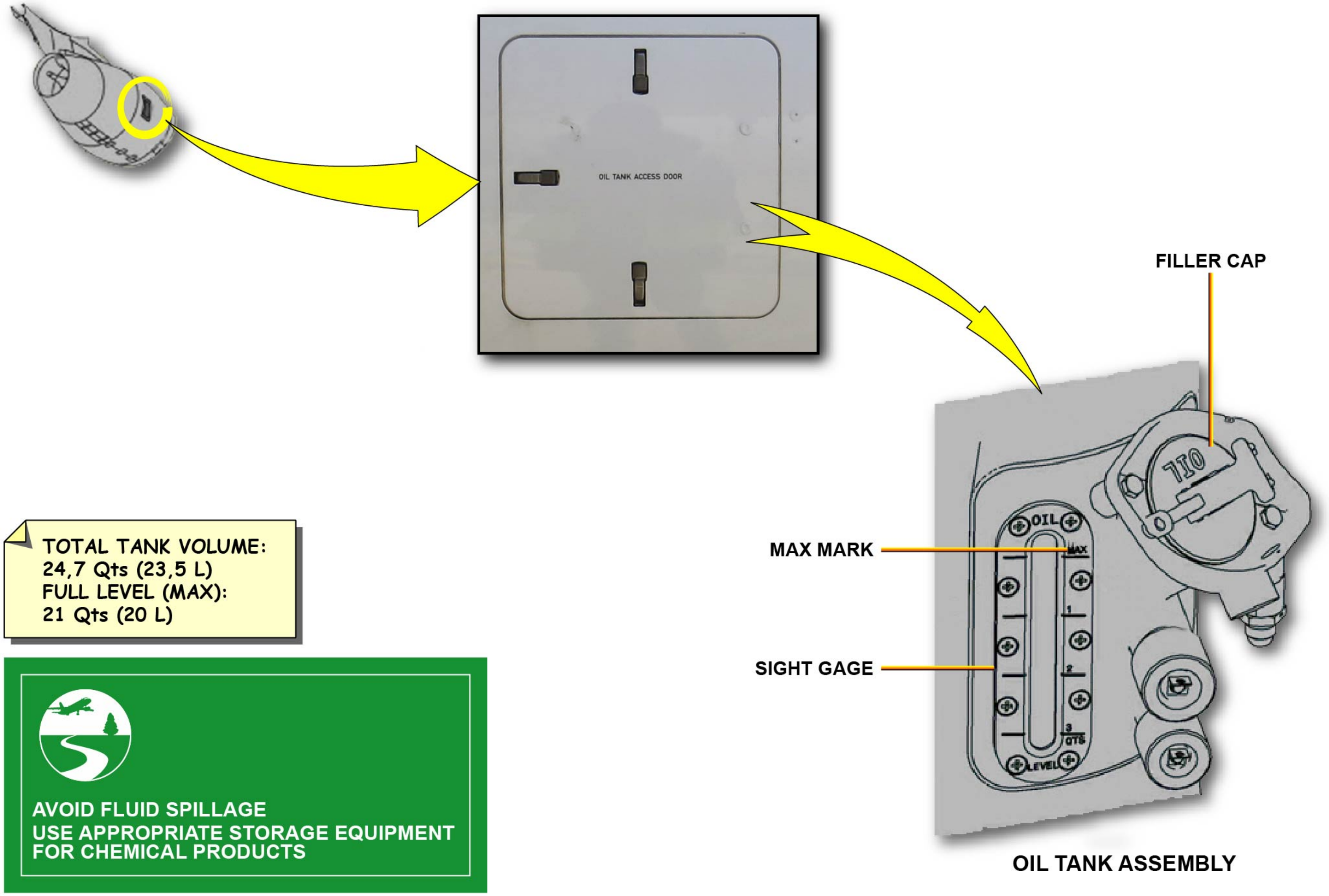
POWER PLANT SYSTEM LINE MAINTENANCE (LEAP)

ENGINE OIL SERVICING

CAUTION: The engine should be shut down for at least 5 minutes prior to oil servicing. This allows the residual pressure in the oil tank to decrease. If you open the filler cap when there is pressure in the tank the hot oil can spray out and burn you.

NOTE: Oil must be added not less than five minutes and not more than 60 minutes after engine shutdown to prevent over-servicing. Do not apply more force than necessary to the handle to open the filler cap.

Procedure:
- open the engine oil servicing access door on right fan cowl,
- check oil level on the sight gage on the oil tank,
- clean the oil tank scupper to prevent contamination during servicing,
- lift the filler cap handle to vertical (unlocked position),
- turn the filler cap handle counterclockwise against its stop to disengage the locking device and remove the filler cap,
- add approved oil as necessary up to the MAX mark on the sight gage,
- examine the O-ring seal on the filler cap for good condition and installation,
- install the filler cap with the handle in the vertical position,
- turn the handle clockwise against its stop to engage the locking device and push it down to the locked position,
- make sure the filler cap is correctly installed,
- close the engine oil servicing access door.


OIL TANK ACCESS DOOR
FILLER CAP
MAX MARK
SIGHT GAGE
OIL
MAX
1
2
3 QTS
LEVEL
OIL TANK ASSEMBLY

TOTAL TANK VOLUME:
24,7 Qts (23,5 L)
FULL LEVEL (MAX):
21 Qts (20 L)

AVOID FLUID SPILLAGE
USE APPROPRIATE STORAGE EQUIPMENT FOR CHEMICAL PRODUCTS

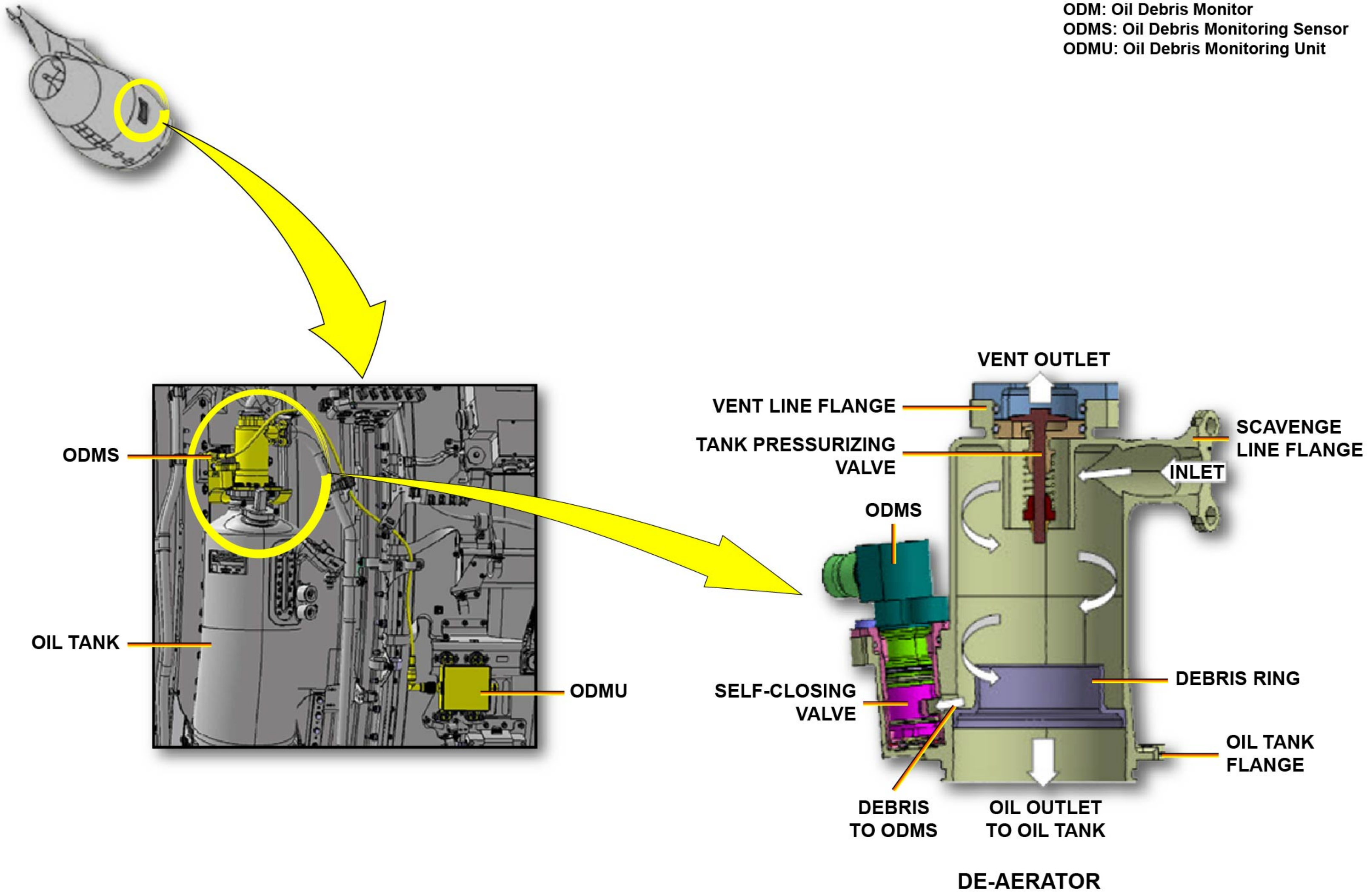
ENGINE OIL SERVICING

POWER PLANT SYSTEM LINE MAINTENANCE (LEAP)

OIL DEBRIS MONITOR (ODM)

The Oil Debris Monitoring Sensor (ODMS) is used to collect ferrous particles from the scavenge oil before returning to the tank.
It is installed in the de-aerator at the top of the oil tank assembly.
When ferrous particles are captured, the ODMS sends an output pulse (proportional to the particles mass) to the ODM Unit (ODMU).
The ODMU amplifies the signal, compares it with a pre-determined threshold and sends it to the Electronic Engine Control (EEC) B.
If the threshold is exceeded, the EECs will generate the ECAM message:
ENG X OIL CHIP DETECTED.
This leads to inspect the ODMS for contamination on the magnetic tip.
If no findings, clean and reinstall the ODMS and perform an oil debris reset and a FADEC test via the MCDU.
If you find oil debris, do a check of the A, B, C, Accessory Gearbox (AGB) and Transfer Gearbox (TGB) sumps scavenge screen plugs for further troubleshooting.

ODM: Oil Debris Monitor
ODMS: Oil Debris Monitoring Sensor
ODMU: Oil Debris Monitoring Unit


ODMS
OIL TANK
ODMU
VENT OUTLET
VENT LINE FLANGE
TANK PRESSURIZING VALVE
SCAVENGE LINE FLANGE
INLET
ODMS
DEBRIS RING
SELF-CLOSING VALVE
OIL TANK FLANGE
DEBRIS TO ODMS
OIL OUTLET TO OIL TANK
DE-AERATOR

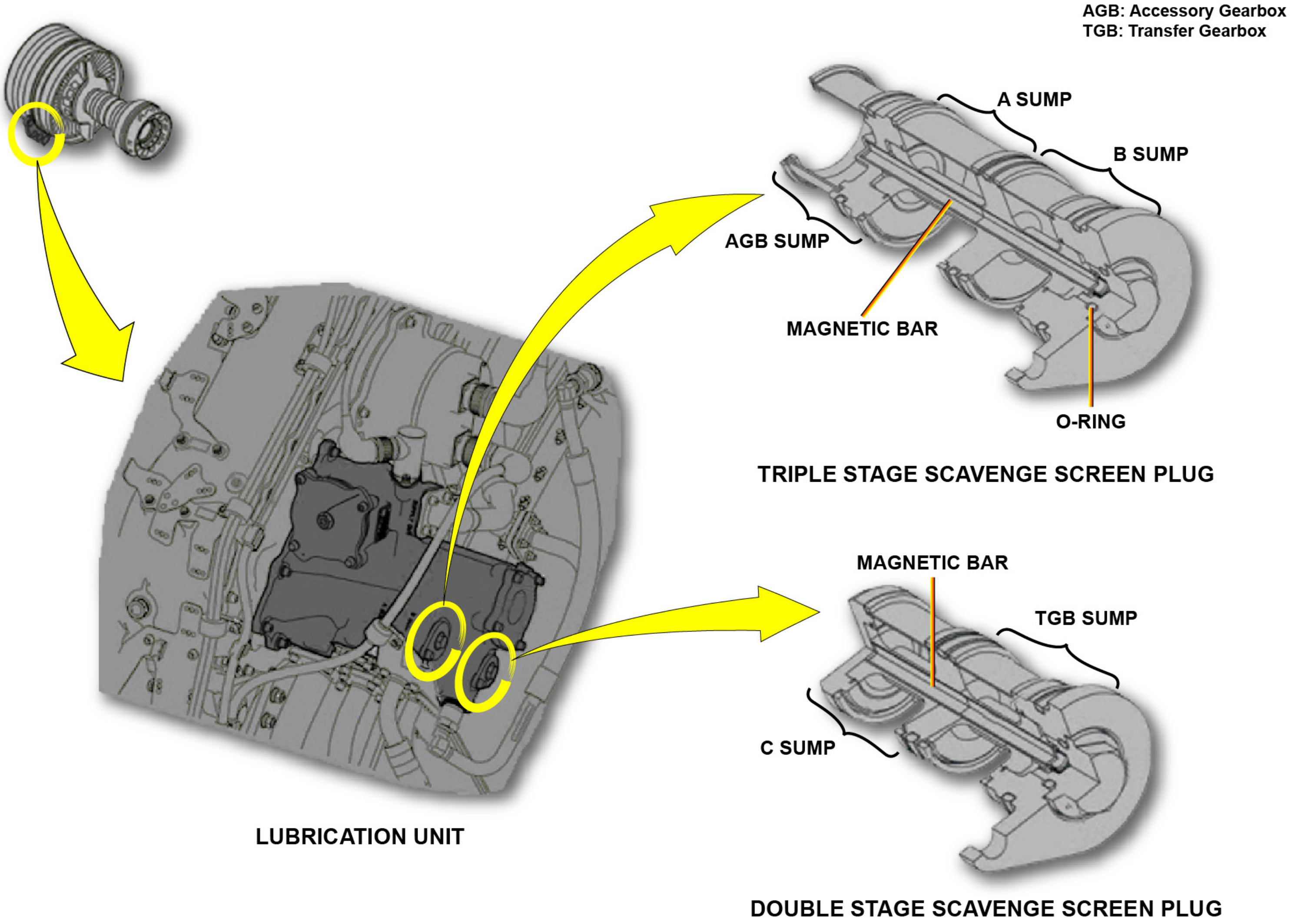
OIL DEBRIS MONITOR (ODM)

POWER PLANT SYSTEM LINE MAINTENANCE (LEAP)

OIL DEBRIS MONITOR (ODM) (continued)

OIL SCAVENGE PROTECTION

The five scavenge pumps of the Lubrication Unit are protected by two scavenge screen plugs named the Triple Stage Scavenge Screen Plug (AGB sump, A sump, B sump) and the Double Stage Scavenge Screen Plug (C sump, TGB sump). Each scavenge screen plug is provisioned to incorporate a magnetic bar in its core.
If the scavenge screen plugs have to be inspected, first drain the Lubrication Unit, then extract the two scavenge screen plugs to collect and analyze the pollution for each sump.


AGB: Accessory Gearbox
TGB: Transfer Gearbox
A SUMP
B SUMP
AGB SUMP
MAGNETIC BAR
O-RING
TRIPLE STAGE SCAVENGE SCREEN PLUG
LUBRICATION UNIT
MAGNETIC BAR
TGB SUMP
C SUMP
DOUBLE STAGE SCAVENGE SCREEN PLUG

OIL DEBRIS MONITOR (ODM) - OIL SCAVENGE PROTECTION

POWER PLANT SYSTEM LINE MAINTENANCE (LEAP)

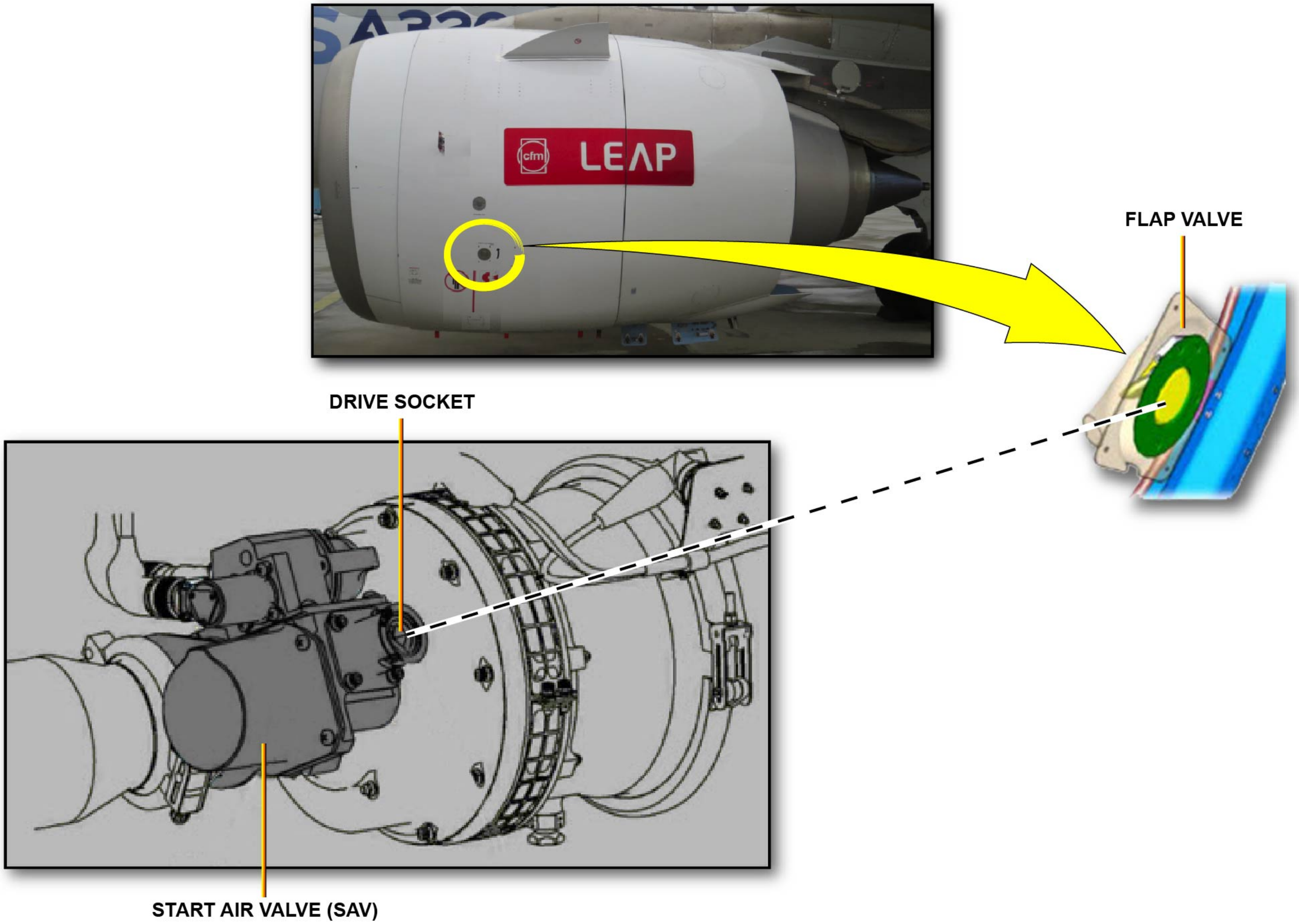
MEL / DEACTIVATION

START VALVE MANUAL OPERATION

In case of an electrical failure of the Start Air Valve (SAV), the SAV can be operated manually to start the engine.
The aircraft may be dispatched per MEL with the valve INOP closed.

WARNING: STAY AWAY FROM THE DANGER AREAS AT THE FRONT AND THE SIDES OF THE ENGINE DURING OPERATION. THE SUCTION IS SUFFICIENT AT THE AIR INTAKE COWL TO PULL A PERSON INTO (IN PART OR FULLY) THE ENGINE. THIS CAN KILL A PERSON OR CAUSE A BAD INJURY.

- First establish the communication with the cockpit (Interphone jack on engine inlet cowl or any other means of communication),
- Insert a 3/8" square drive extension into the SAV manual wrench socket through the flap valve on the lower part of the LH fan cowl,
- Make sure that the SAV is in the closed position (the valve is spring-loaded to the close position),
- On command from the cockpit, turn the valve shaft counterclockwise to its stop, this opens the butterfly valve,
- Hold the valve open until the cockpit requests to close the valve,
- Remove the tool and leave the position through the safety corridor.

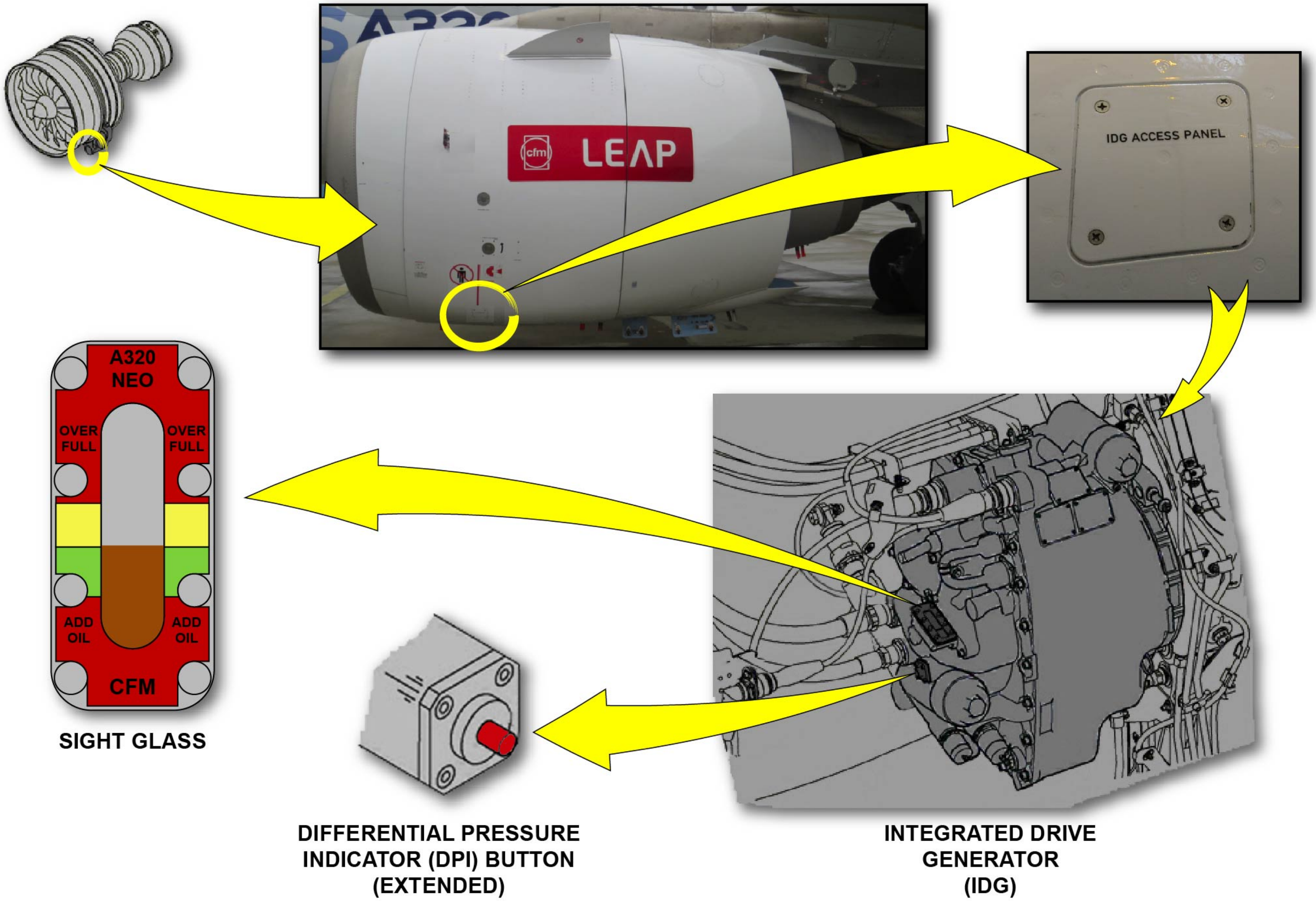

FLAP VALVE
DRIVE SOCKET
START AIR VALVE (SAV)

MEL / DEACTIVATION - START VALVE MANUAL OPERATION

POWER PLANT SYSTEM LINE MAINTENANCE (LEAP)

IDG SERVICING

The Integrated Drive Generator (IDG) is monitored by several devices: an internal oil level sensor, a mechanical filter Differential Pressure Indicator (DPI), a sight glass, two internal oil temperature sensors (in and out heat exchanger circuit connections).
The accurate oil level depends on the detected temperature displayed on the ELEC System page.
Let the oil become stable for a minimum of five minutes after engine shutdown.
For IDG oil level check, an access panel is located on the lower part of the left fan cowl.
If the level is below the middle of the green band, add oil.
In case of over servicing (cold oil above the yellow band or hot oil in the yellow band), it is necessary to drain the excess.
For IDG oil servicing, the left fan cowl has to be open to access the pressure filling and overflow ports.
If the IDG oil filter DPI is extended (red button visible), do the relative troubleshooting procedure.

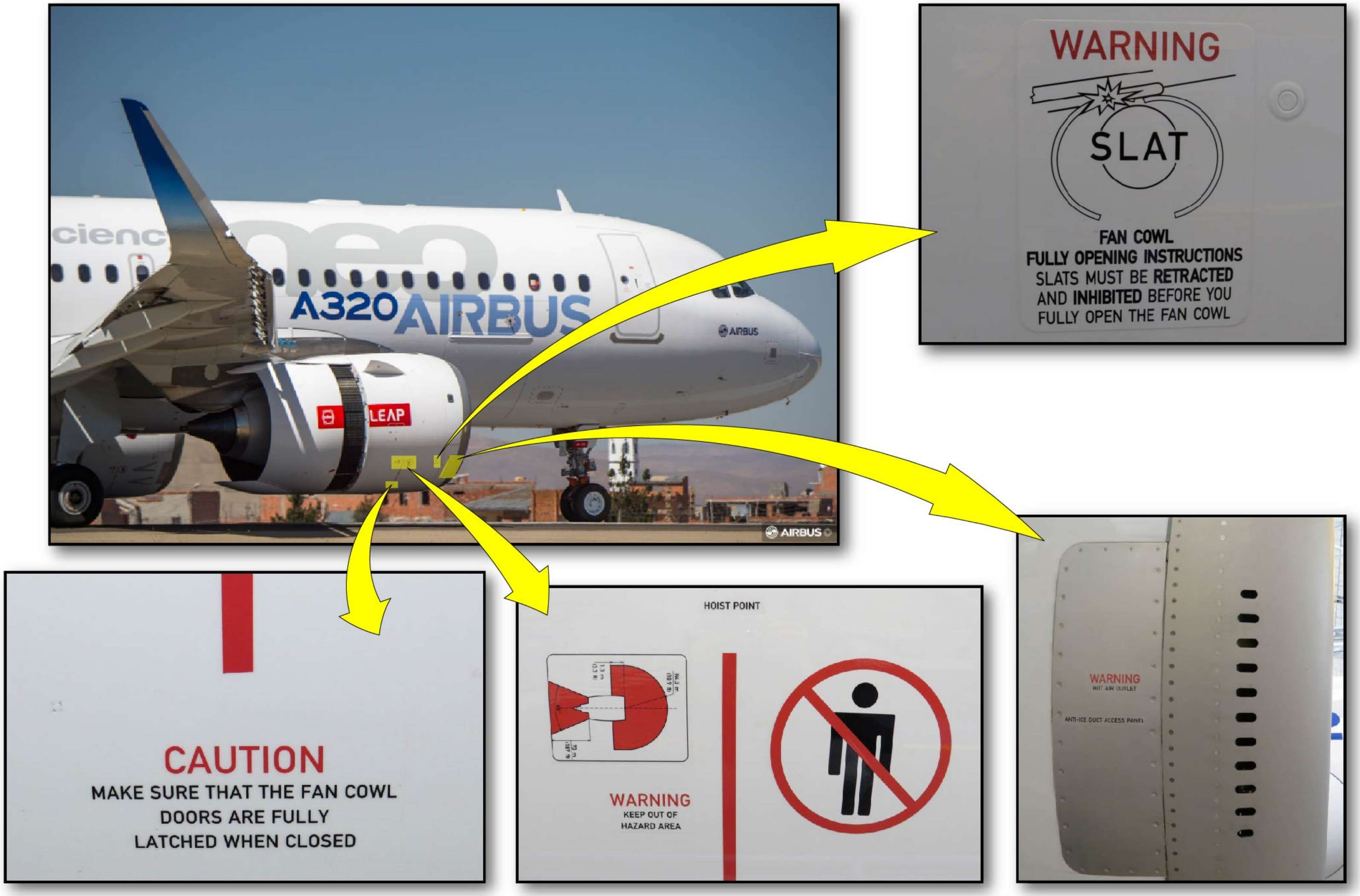

LEAP
IDG ACCESS PANEL
A320
NEO
OVER FULL
OVER FULL
ADD OIL
ADD OIL
CFM
SIGHT GLASS
DIFFERENTIAL PRESSURE INDICATOR (DPI) BUTTON (EXTENDED)
INTEGRATED DRIVE GENERATOR (IDG)

IDG SERVICING

POWER PLANT SYSTEM LINE MAINTENANCE (LEAP)

SAFETY PRECAUTIONS

Follow the General Warnings and Cautions, related Safety Data and Standard Precautions for Maintenance Procedures.


A320 AIRBUS
LEAP
AIRBUS
WARNING
SLAT
FAN COWL
FULLY OPENING INSTRUCTIONS
SLATS MUST BE RETRACTED
AND INHIBITED BEFORE YOU
FULLY OPEN THE FAN COWL
CAUTION
MAKE SURE THAT THE FAN COWL
DOORS ARE FULLY
LATCHED WHEN CLOSED
HOIST POINT
WARNING
KEEP OUT OF
HAZARD AREA
WARNING
HOT AIR OUTLET
ANTI-ICE DUCT ACCESS PANEL

SAFETY PRECAUTIONS

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